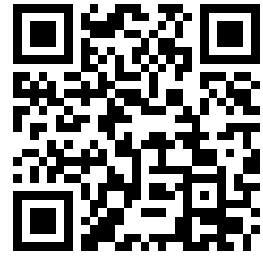

TM 11-2103

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

BASIC MAINTENANCE PRACTICES (STEP-BY-STEP DIAL CENTRAL OFFICE EQUIPMENT)

DEPARTMENT OF THE ARMY • JUNE 1950

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DEPARTMENT OF THE ARMY *JUNE 1950*

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BY ORDER OF THE SECRETARY OF THE ARMY:

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The Adjutant General

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CONTENTS

CHAPTER 1

INTRODUCTION

1. Scope

These instructions are published for the information and guidance of maintenance personnel for step-by-step dial central office equipment. They outline the type of troubles commonly encountered and describe the equipment and the methods used in locating these troubles. They also describe the use of the tools supplied with the equipment and give the recommended methods of using test equipment in routine inspection tests. The wiring diagrams, standard adjustment sheets, and other drawings supplied for each step-by-step dial central office by the equipment manufacturer also are discussed. These instructions apply specifically to step-by-step dial central office equipment manufactured by the Automatic Electric Company, but are generally applicable to step-by-step equipment of other manufacture.

2. Appendixes

a. Appendix I contains lists of pertinent reference material, including the fourteen other technical manuals in the series on step-by-step dial central office equipment.

b. Appendix II is a glossary of the abbreviations used in this manual. Refer to TM 11–2100 for a complete glossary of terms used in the fifteen technical manuals in the step-by-step dial central office series.

3. Forms and Records

a. One of the following forms will be used for reporting unsatisfactory conditions of equipment:

(1) DA AGO 468 (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700–45–5.

(2) AF Form 54 (Unsatisfactory Report) will be filled out and forwarded to Commanding General, Air Matériel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700–45–5 and AFR 65–26.

b. The forms and records used (par. 38) in maintaining step-by-step dial central office equipment are listed in appendix I. These forms may be obtained through normal AG supply channels.

CHAPTER 2

MAINTENANCE INSTRUCTIONS

Section I. TEST EQUIPMENT, TOOLS, AND MAINTENANCE MATERIALS

4. Test Sets and Testing Equipment

The test equipment listed in table I is furnished by the manufacturer and is required for maintenance routines in step-by-step dial central offices. For illustrations and additional information on this test equipment, refer to TM 11–2111. Refer also to TM 11–2106, TM 11–2110, TM 11–2112, TM 11–2113, and TM 11–2114, which pertain to individual test-equipment units.

Table I. Test Sets and Equipment Furnished by Manufacturer

Auto elec. part No.	Item
H–64645–1	Current-flow test set.
H–45987–1	Connector routine test set.
H–55165–B	Stepping-switch test set.
H–88459–1	Wire chief's test desk.
D–70181–B	Volt-ohm-milliammeter (part of test desk).
H–69714–1	Wheatstone bridge (part of test desk).
H–16339–1	Test lamp.
L–965–AO	Test telephone handset.
D–235695–C	Test distributor (part of step-by-step dial central office test switch train).
D–857060–A	Reverting-call switch (test ring-back switch) (part of step-by-step dial central office miscellaneous switching equipment).

5. Tools and Tool Equipments

a. The special tools supplied by the manufacturer which are required for the adjustment and repair of step-by-step dial central office equipment are listed in table II. Common hand tools are not included, and must, therefore, be obtained through regular supply channels. Other suggested tools obtainable from standard Signal Corps tool equipments are contained in DA Supply Catalog SIG 6. Refer also to TM 11–2111 for further information on tools supplied by the equipment manufacturer.

Table II. Special Tools Supplied by Manufacturer

Signal Corps stock No.	Auto elec. part No.	Tool and description
4D20777	H–20777	Adjuster, spring (relay contact).
6R41572	H–42873	Do.
6R41578	H–14768	Adjuster, armature lever.
4D7067	H–7067	Adjuster, spring (switch detents).
4D20179	H–20179–1	Adjuster, spring (rotary switch).
6Q187–5	H–47202	Adjuster, spring (normal post cam).
6Q188	H–88385	Adjuster, spring (lever switch).
6Q188–2	H–88504–1	Adjuster, spring (relay contact).
6Q188–3	H–88504–2	Do.
6Q188–5	H–88503–1	Adjuster, spring (relay armature).
6Q188–4	H–88502–1	Do.
6Q188–1	H–56518	Adjuster, spring (a-c (alternating-current) relay armature).
6R41574	H–14769	Bender, armature stop.
6R41065C	.....	Burnisher, WECo 265C (for relay contacts).
6M213	.....	Brush, switch bank contact cleaning, WECo 389A.
	D–730370	Bracket, for test telephone handset.
4D16590–1	H–16590–1	Cleaner, switch bank contact.
4D16590–2	H–16590–2	Do.
6Q18018	H–46556	Case, tool.
	D–15455	Clip, for busying switches.
6R41353A	.....	Extractor, lamp, WECo 553A.
6R41119	.....	Extractor, lamp cap, WECo 319A.
6R41570	H–46795–1	Gage, thickness, 9-leaf (for adjusting Auto Elec relay residual screws).
6Q45726	.....	Gage, thickness, 26-leaf, Lufkin 123 (for general-purpose checking and adjusting).
NSN	H–14315	Kit, fuse repair.
6Z6941–1	H–16339–1	Light, test (for continuity testing).
6R40858	.....	Pliers, heat coil extractor, for WECo heat coils.
	H–44514	Pliers, heat coil extractor, for Auto Elec heat coils.
4D16290	H–16290–7	Pliers, adjuster (for switch contact springs and dial mechanism).
6R4607	.....	Pliers TL–107, side cutter.

Table II. Special Tools Supplied by Manufacturer—continued

Signal Corps stock No.	Auto elec. part No.	Tool and description
6R4735–5	H-50620	Pliers, duck-bill, 5" long (for adjusting switch contact springs).
6R4626	H-50619	Pliers TL–126, 6", straight, long-nose.
6R4741–5A	311	Pliers, flat nose, smooth, Klein 311.
6R4770–6	.....	Pliers, spring adjuster, 6", round-nose.
6Z8165	D–542539–A	Sleeving, cotton (75 ft), for bank contact cleaners.
6R18339	H–21766	Screw driver, offset.
6R16011	H–24664	Screw driver, 6".
6R40841/1	95	Screw driver, cabinet, 3½".
	H–15799	Stand, test, for switch repair.
4D26917	H–26917	Tool, dial escutcheon.
6R55507–8	H–7062	Wrench, open end, for relay residual.
6R57210–12–1	H–7063	Wrench, open end, 5/16" and 3/8".
6R57407–1	H–46440–1	Wrench, socket, 7/32".
	H–46437–1	Wrench, socket, 3/16".
4D23865	H–23865	Wrench, open end, for adjusting rotary switch armature screws.
6R57697–2	M–6656–1	Wrench, jack strip fastener.
6Q48541	M–6656–2	Wrench, guide for jack strip wrench.

b. Common tools needed for step-by-step dial central office maintenance are contained in DA Supply Catalog SIG 6, TE–49, TE–111, and TE–112.

Note. Since a gram tension gage which measures up to 450 grams tension is required, but not furnished by the manufacturer or included in the tools obtainable from Tool Equipments TE–49, TE–111, or TE–112, (the two gram tension gages, WECo 70D and 70J, in TE–112, measuring only up to 50 grams and 150 grams, respectively) a gram tension gage of greater tension-measuring capacity, such as WECo 62B (0–700 grams) or WECo 79B (0–1,000 grams) should be obtained through regular supply channels.

6. Maintenance Materials

a. Materials contained in DA Supply Catalog SIG 6, ME–10 are necessary in the maintenance of step-by-step dial central office oquipment. Refer to TM 11–2111 for details on general maintenance supplies.

b. The following are maintenance parts initially supplied by the manufacturer with a typical step-by-step dial central office:

Table III. Maintenance Parts Supplied by Manufacturer

Signal Corps stock No.	Auto elec. part No.	Quantity	Part and description
	R–7948–A4B	10	Line and cut-off relay.
3Z6020–247	D–281410–A	8	Resistor, suppressor, 200-ohm.
3C1121–32	D–281455	4	Release magnet coil.
3C1121–33	D–281530	3	Rotary and vertical magnet coil.
4D46088	D–46088	2	Shaft, for selector.
4D46099A	D–46099–A	2	Shaft, for linefinder.
4D46176	D–46176	2	Shaft, for 200-point connector.
4D46218	D–46218–A	2	Shaft, for 100-point connector.
4D46270A	D–46270–A	5	Contact wiper (200-point switch) with cord holder.
4D46271A	D–46271–A	3	Contact wiper (100-point switch).
4D46273A	D–46273–A	5	Contact wiper for control banks.
4D46274A	D–46274–A	6	Contact wiper for line banks of 100-point selector.
3E4057–4.75	D–542281–A	6	Cord, for bank contact wipers.
	D–542282–A	5	Do.
3E4057–7.5	D–542283–A	5	Do.
3E4057–9	D–542284–A	5	Do.
3E4057–11.25	D–542285–A	5	Do.
4D71262A	D–71262–A	2	Armature, for relay.
3Z381–1	D–71163	2	Do.
3Z381–2	D–71164	2	Do.
4D71166	D–71166	2	Armature, for release magnet.
4D71169	D–71169	2	Armature, for rotary stepping magnet.
4D71250	D–71250	2	Do.
4D71343A	D–71343–A	2	Armature, for vertical stepping magnet.
3Z9580–6.25	D–735002	2	Contact assembly, rotary interrupter springs.

Table III. Maintenance Parts Supplied by Manufacturer—continued

Signal Corps stock No.	Auto elec. part No.	Quantity	Part and description
3Z9580–6.26	D–735004	2	Contact assembly, cam springs.
3Z9580–6.29	D–735022	2	Do.
3Z9580–6.18	D–735066	2	Contact assembly, rotary interrupter springs.
3Z9580–6.19	D–735114	2	Contact assembly, vertical interrupter springs.
4C1914	MC–67704–A	2	Lens, indicator light, white (lamp cap).
4C1915	MC–67705–A	2	Lens, indicator light, red (lamp cap).
4C1916	MC–67706–A	2	Lens, indicator light, green (lamp cap).
3G1838–42.21	D–44670–A	20	Insulator (for protector blocks).
	D–44671	20	Insulator (for protectors).
	D–44674	20	Insulator.
	D–44866	20	Do.
	D–67166	20	Block, protector (carbon).
	D–67167	20	Do.
	D–68181–B	20	Heat coil (2.7-ohm).
	D–108088	5	Spring (protector).
	D–108091	5	Do.
	D–108092	10	Do.
	D–108093	5	Do.
	D–108094	5	Do.
	D–108096–A	5	Do.

Section II. PREVENTIVE MAINTENANCE

7. Meaning of Preventive Maintenance

PM (preventive maintenance) is a systematic series of operations performed at regular intervals on equipment to eliminate major break-downs and unwanted interruptions in service, and to keep the equipment operating at top efficiency. PM differs from repair in that it is intended to *prevent* break-downs and, therefore, eliminates the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct existing defects. The importance of PM cannot be over-emphasized. The entire wire communication system depends upon its being *in operation* when it is needed, and upon its *operating efficiency*. PM should, therefore, be considered as a series of routine inspections which provide insurance against operational failures and major repairs.

8. Preventive Maintenance Procedures

a. GENERAL. Most of the electrical parts used in step-by-step dial central offices require routine PM, but differ in the amount and kind of PM required. Frequency of PM tests and inspections is governed by the type and age of the equipment, and the conditions under which it must operate. This section of the manual is intended as a guide for personnel performing the basic PM routines.

Note. PM practice, performed at regular intervals, will minimize deterioration of step-by-step dial central office equipment throughout the entire period of operation. The extent of deterioration of the equipment depends on the method of maintenance used from the start and not after deterioration has already begun.

b. INSPECTION. Make periodic inspection of the equipment to detect minor defects and signs of worn, damaged, or corroded parts which may later cause trouble. Although these minor defects may not have interfered with the performance of the equipment, correcting them before they lead to major break-downs saves valuable time and effort. Become thoroughly familiar with the indications of normal functioning, so you can recognize the signs of defective equipment. Inspection consists of observing all parts of the equipment carefully, noticing their color, placement, state of cleanliness, and signs of wear or corrosion. Inspect for the following conditions:

(1) *Overheating.* Look for discoloration, blistering, or bulging of the parts or surface of a cover; leakage of insulating compounds; and oxidation of metal contact surfaces.

(2) *Placement.* See that all leads and cabling are in their original positions, that insulation has not become damaged, and that soldered connections are in good condition.

(3) *Cleanliness.* Carefully examine all recesses

in the units for accumulation of dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(4) *Tightness.* Check any connection or mounting which appears to be loose.

Caution: Do not tighten screws, bolts, and nuts carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken. Do not confuse adjusting screws with mounting screws. Perform cleaning operations carefully, in order not to damage equipment or change its adjustment.

(5) *Lubrication.* Observe the condition of the grease or oil on the switch shafts, bearings of motors, and other moving parts requiring lubrication.

c. ROUTINE TESTS. To prevent interruptions of service and maintain high operating efficiency, make periodic tests of the switching equipment, repeaters, trunk lines, and relay equipments to determine whether the equipment is functioning properly or is in need of repair or adjustment. These periodic tests are scheduled work and are usually called routine tests. For test equipment required in performing these routine tests, refer to paragraph 4 and to TM 11–2111.

9. Switchroom Cleaning and Conditioning

Dust or dirt in the switchroom causes excessive equipment failures, since it eventually filters into the working parts. Moisture and humidity also cause equipment failures through rust and corrosion of metal, or electrolysis and insulation leakage in electrical apparatus. Take every precaution to exclude dust, dirt, moisture, or insects from the switchroom, and to keep the equipment clean and dry. Reduce or prevent unnecessary travel of personnel through the switchroom to avoid introduction of dirt or dirt-laden air.

a. GENERAL CLEANING. Remove accumulated dust and dirt from the equipment with a clean, lint-free cloth. Use camel's-hair brush TL–72 or similar camel's-hair brushes to remove dust from relay or switch assemblies, where space is restricted. Keep all parts of the switchroom as clean as possible. Linoleum or a similar floor covering is desirable. Keep it lightly waxed, and clean it at regular intervals with a mop dampened very lightly with water. For switchrooms without floor covering, use a push-broom and sweeping compound. Do not use any wax, sweeping compound, or other cleaning materials known to contain turpentine or other volatile substances likely to generate fumes, since the relays used in step-by-step dial central office equipment are easily made inoperative by slight films deposited on the contacts. These fumes cause service interruptions, and necessitate cleaning and burnishing of contacts in all relays. The common self-polishing types of floor wax are usually suitable for use on switchroom floor coverings.

Note. Do not use gasoline as a cleaning fluid for any purpose. Instead, use Solvent, dry-cleaning (SD), which is available as a cleaning fluid through established supply channels. Use carbon tetrachloride as a cleaning fluid only when inflammable solvents cannot be used because of the fire hazard, and when cleaning electrical contacts in relay switches and similar equipment.

b. VENTILATION. Ventilation or forced air circulation is sometimes necessary for the comfort of personnel in step-by-step dial central offices. Outside air drawn into the switchroom must be passed through filters. Only filtered, dust-free air should be circulated in the switchroom. Seal any windows, unnecessary doors, or other openings into the switchroom to prevent entrance of dirt-bearing unfiltered air. Inspect and clean air filters frequently. Replace air filters that cannot be kept serviceable. In well-planned installations, the use of air conditioning eliminates the need for outside ventilation.

c. HUMIDITY. When high humidity prevails, the dial central office equipment must be protected from moisture damage. High humidity is usual in tropical regions and may sometimes occur under adverse weather conditions in temperate zones, especially along seacoasts or in areas having a considerable difference between day and night temperatures. Relative humidity, an expression of the moisture content of air, is the percentage of moisture actually present in a given volume of air compared to the maximum which the air can evaporate and hold. Heating the air increases its capacity to evaporate and hold moisture, and therefore reduces the *relative* humidity. When air cools, its capacity to hold moisture is reduced, causing its *relative* humidity to rise. If warm moist air comes in contact with cold equipment, the sudden cooling causes it to deposit its moisture in the form of dew. To avoid moisture troubles, keep the switchroom relative humidity below 60 percent, and never above 70 percent. Use hygrometers, one in the switchroom and one outdoors, to provide percent humidity indications.

d. AIR CONDITIONING. A unit-type air conditioner, using a refrigerated cooling system, provides the most effective protection against high humidity. Air from the switchroom is circulated over the cooling coils, giving up its moisture, and is returned to the switchroom through a dust filter. The resultant dry, dust-free, and cooled air insures best equipment performance and also contributes to the comfort of operating personnel. Keep the air-conditioning system in operation when humidity is high, regardless of room temperature, and do not turn it off when it is not required for the comfort of personnel. When the temperature is uncomfortably low, requiring heat in the switchroom, turn off the air-conditioning unit and control the relative humidity by artificial heat. Some air-conditioning units can be operated to reduce humidity without appreciable room cooling by recirculating the air used to cool the condenser. This type of air conditioner can therefore be used when the temperature is too low for comfort, but the relative humidity is high. Maintain air-conditioning units carefully, in accordance with the instructions furnished by the manufacturer.

e. HEATING.

(1) Relative humidity in the step-by-step dial central office may also be controlled by heating the air in the room. This increases the capacity of the air to retain moisture and reduces condensation and absorption troubles. An increase in temperature of 4° F. reduces relative humidity about 10 percent, or a decrease in temperature of 4° F. increases the humidity 10 percent. Thus, when the relative humidity is 90 percent, too high for safety, an increase of 12° F. in switchroom temperature will reduce the relative humidity to 60 percent. Do not allow the switchroom temperature to rise and fall with variations in day and night temperatures unless humidity control is provided. Steam or hot-water central heating, or any other method in which combustion takes place outside the switchroom, is satisfactory. Heating by means of stoves located in the switchroom is unsatisfactory, because of the fumes, smoke, and soot likely to be released. Always locate the heating unit and fuel in a separate room which has a satisfactory flue outlet and ventilation.

(2) Use electric strip heaters where existing heating facilities are inadequate. A standard 230-volt, 500-watt electric strip heater operated on 110 volts ac, at 125-watt power dissipation, will provide a safe source of heat. This unit operates at 430° F. instead of its normal 750° F. temperature on full voltage. One heater per six uprights on the CDF (combined distributing frame), and one heater for each switch bay are often satisfactory. Determine the requirements for each office individually, however, since the size of the rooms and type of building construction vary. Locate the heaters so that no danger exists of overheating any adjacent equipment. Do not place heaters close to combustible material. For the test desk and attendant's switchboard, use a single 40-watt, 110-volt lamp per position, mounted in a free and clear space inside the cabinets. Use electric heater units equipped with fans both to dry out equipment and to heat the room.

10. Power and Ringing Equipment

Two diverter-pole motor generators are used for charging the step-by-step dial central office storage batteries. Perform the following PM routines on the motor generators, ringing machines, rectifiers, and miscellaneous power and supervisory relays mounted on the power board:

a. MOTOR GENERATORS.

(1) Check the motor generators for general cleanliness. Wipe all dust and oil from the exterior surfaces of the machines with a clean cloth slightly dampened with solvent (SD). Clean the piers or base on which the machines rest when cleaning the switchroom floor.

(2) Clean the commutators with a special commutator cleaning tool (fig. 1), which can be made as follows: Wrap 16 layers of 6- or 8-ounce hard-woven canvas or duck over the end of a strip of strong, pliable wood, 1 to 3 inches wide, ⅜ inch thick, and 9 inches long. Attach the canvas to the wooden strip with two rivets. Countersink the hardwood strip at the points where the rivets are inserted to prevent the rivet heads from coming in contact with the commutator. When the outer canvas layer wears away or becomes too dirty for further use, cut it away and expose the next layer.

Refer to TM 11–2108 for further details of the construction and use of this special commutator cleaning tool.

(3) Check for possible pitting or grooving of the commutator. If this condition exists, stop the motor generators, lift the brushes, and rub the brush contact faces and the commutator face with the commutator cleaning tool (fig. 1).

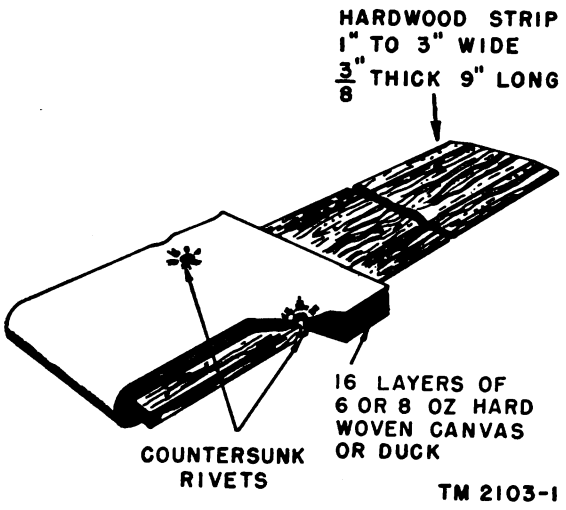


Figure 1. Commutator cleaning tool.

(4) Clean all dust and dirt from commutator brushes and brush holders with the commutator cleaning tool (fig. 1).

(5) Clean the undercutting between the commutator segments to remove any copper, carbon dust, or other foreign material. Use a thin flat piece of fiber or wood for this purpose.

(6) Commutator segments may wear to the point where the mica insulation between them is above the surface of the commutator. Keep the mica always about one-thirty-second inch below the surface of the commutator segments. Use a knife or broken hack-saw blade on which the teeth have been ground off to cut the mica down to the required depth. Clean the mica slots or undercuts.

(7) Inspect bearings for proper lubrication. If necessary, clean bearings and lubricate in accordance with lubrication instructions (par. 26).

(8) Check the floating voltage, by reading the generator output meter on the power board. Normal floating voltage should be 2.15 volts on 23-cell operation, with a low limit of 2.10 volts per cell and a high limit of 2.20 volts per cell.

(9) Check the automatic paralleling of the two motor generators, making sure that motor generator No. 2 starts when the load rises above the normal output of motor generator No. 1, and stops when the load falls below the normal output of motor generator No. 1. Perform this automatic paralleling test by first reducing, then increasing the load and observing whether each machine cuts off at the proper load and in the proper sequence.

b. Ringing Machines.

(1) Clean dust and oil from all exterior surfaces of the ringing machines with a dry, clean cloth. When grease or oil film is present, slightly dampen the cloth with solvent (SD).

(2) Inspect the collector rings and commutators for excessive wear and scoring. Clean these when necessary.

(3) Inspect bearings for proper lubrication while the machines are not in motion. Add oil, if necessary, in accordance with lubrication instructions (par. 25).

(4) Inspect the worm and gear for signs of wear. (Lubrication of the worm and gear on ringing machines using a steel worm and a composition fiber gear is not recommended by the manufacturer.)

(5) Check the interrupter springs and cams for proper operation. Test the make and break contact pressure. Inspect the interrupter contact points for burned or pitted conditions. Clean if necessary.

c. End-Cell Rectifier.

(1) Open the case, and clean dust or dirt from the exposed parts with a camel's-hair brush.

(2) Check output voltage and current. Check the end cells of the main battery (the three reserve cells, Nos. 24, 25, and 26) to see if they are overcharging or are undercharged in relation to the exchange load, and adjust the charging rate as required.

d. Miscellaneous Power and Supervisory Equipment.

(1) Check the power and supervisory relays, and the ringing machine transfer relays, following the same procedure used in other relay group inspections (par. 18).

(2) Inspect relay contacts for burned or pitted conditions. Examine relay contacts for exceptional arcing. Clean and adjust relay contacts if necessary (par. 57). Operate the armature of each supervisory and alarm relay to make sure that all the signal lamps and alarms function normally.

(3) Inspect relay terminals for poorly soldered or loose connections.

(4) Check wiring and forms for proper arrangement and condition of insulation.

(5) Inspect all fuse panels for tightness. Check each screw with a screw driver. Replace any temporary fuses with fuses of the proper type and proper electrical rating.

(6) Inspect the supervisory or alarm lamps for loose bases or damaged sockets. Make sure that each lamp is of the proper voltage, color and type, and has normal brightness.

11. Batteries

Perform the following PM routines on storage batteries:

a. Clean the top of the battery with a bristle (nonmetallic) brush. Clean the battery terminals with a cloth dampened with a diluted solution of bicarbonate of soda. Use bicarbonate of soda to neutralize any spilled electrolyte.

Caution: Use rubber gloves and goggles when performing PM on storage batteries.

b. Check the internal temperature of the cells and the room temperature. Enter the readings on the DAAGO Form 11–24 (Weekly Storage Battery Report).

c. Check the specific gravity of each cell with a hydrometer. Enter the readings on DAAGO Form 11–24.

d. Check the level of the electrolyte. It should be one-half inch above the tops of the separators. Add distilled water to the cells until this height is reached.

12. Distributing Frames and Terminal Blocks

The distributing frames and terminal blocks require very little PM. Perform the following PM routines on distributing frames and terminal blocks:

a. Clean the distributing frames and terminal blocks with a bristle brush, or use a vacuum cleaner suction tool if one is available. Tap the terminal blocks lightly while using the vacuum cleaner, so that particles of solder or dirt are dislodged for easier removal.

b. Inspect wiring, cabling, and jumpers for signs of chafing and deteriorated insulation. Inspect all soldered connections for looseness and granular condition. Tighten any loose bolts and nuts, being careful not to strip the threads.

c. Examine protectors for defective blocks and operated heat coils. Inspect heat coils to see that they are properly engaged in the mounting springs.

d. Check tell-tale lamps for operation, and for looseness in sockets.

e. Inspect the connector plug (test shoe) on the test cable. Clean and adjust its contacts if necessary.

13. Two-motion Stepping Switches (figs. 21 and 22)

The basic vertical and rotary stepping mechanisms used in linefinders, selectors, and connectors are very similar. These stepping switches differ chiefly in the type and number of relays, circuit interrupters, and auxiliary switches which they use, and in their method of operation. Perform the following PM routines on all two-motion stepping switches (figs. 21 and 22).

a. If preliminary inspection indicates that extensive readjustments must be made, or that worn or damaged parts must be replaced, remove the switch from the shelf as described in paragraph 47. Make the adjustments and repairs at the workbench. Follow the adjustment procedures outlined in paragraphs 46 and 48.

b. Operate the busying switch on those stepping switches equipped with it. Remove the switch cover.

c. Inspect and clean relays (par. 57).

d. Inspect and clean all contact assemblies, such as the vertical-off-normal contact assembly and the rotary interrupter (par. 50*a*).

e. Check for loose mounting screws and nuts. Check the locknuts on the adjusting screws. Tighten where necessary, but take care that adjustments are not altered. If any readjustments are necessary, follow instructions in paragraphs 46 and 48.

f. Inspect the switch shaft for lubrication. Clean and lubricate if necessary (par. 21). See that the switch shaft operates freely and does not bind. Scoring or excessive wear of the rotary ratchet teeth indicates that either the double detent or the rotary pawl requires adjusting. Adjust as outlined in paragraph 48.

g. Check the vertical and the rotary armatures for

binding or excessive play. Adjust if necessary (par. 48).

h. Check the double detent for binding or excessive play. Adjust if necessary (par. 48).

i. Raise the switch shaft to the first bank level by operating the vertical armature by hand. Advance the bank wiper assemblies to the first contact on the first bank level by manually operating the rotary armature. Press the release armature. The wipers should disengage and the switch shaft should drop to the OFF position. Failure to do so indicates either insufficient tension on the helical shaft spring or excessive drag by wiper tips on switch bank contacts. Increase the shaft spring tension by unlocking the shaft spring cap from the shaft and rotating the cap one-fourth turn in a clockwise direction. If normal operation is not obtained (that is, if the switch shaft is not restored to its normal position from any rotary step on the first level) after advancing the shaft spring one-half turn, inspect the wiper tips and switch bank contacts.

14. Switch Bank Cleaning

The contact banks of all switches should be cleaned periodically. The interval of cleaning depends upon local factors, as evidenced by the condition of the contacts. Clean the banks as often as required to keep the contact action reliable.

a. Remove loose dust from the switch bank contacts with a special brush formed for this purpose. If a standard bank contact cleaning brush (WECo 389A or similar type) is not available, make a brush from an ordinary plastic-handled tooth brush. Place the bristle portion in hot water. When the brush is heated sufficiently to become flexible, remove it from the water, and bend the bristle end in a semicircle, with the bristle portion on the outside. Allow the brush to dry thoroughly before using.

b. Cut a length of cotton sleeving (Auto Elec D–542539–A) sufficient to cover and extend over the blades of switch bank contact cleaning tools (Auto Elec H–16590–1 and H–16590–2) (fig. 2). Switch bank contact cleaner (Auto Elec H–16590–1) is used to clean and polish the contacts of 200-point switch banks. Switch bank contact cleaner (Auto Elec H–16590–2), which has a thicker blade, is used to clean the contacts of 100-point switch banks. Slide the cotton sleeving over the blade of the cleaning tool. Hook the end of the sleeving firmly in the notch in the blade near the tool handle. Draw the cotton sleeving taut over the blade. Force the tip of the blade through the cotton sleeving to hold it tight.

c. Place the sleeve-covered blade of the cleaning tool between adjacent levels of contacts in the switch bank. Rotate the handle of the cleaning tool back and forth through an arc of approximately 90°, keeping the tool in alinement with the switch bank contacts. When the contacts are clean and polished, move the cleaning tool to the next levels. Repeat this procedure until all contacts in the bank have been cleaned.

Caution: Replace frayed or worn sleeving on the cleaning tool to avoid snagging and damaging the contacts. Be careful not to damage the contact wipers. Do not clean the contacts of any switch except when its wipers are at normal and off the contact banks.

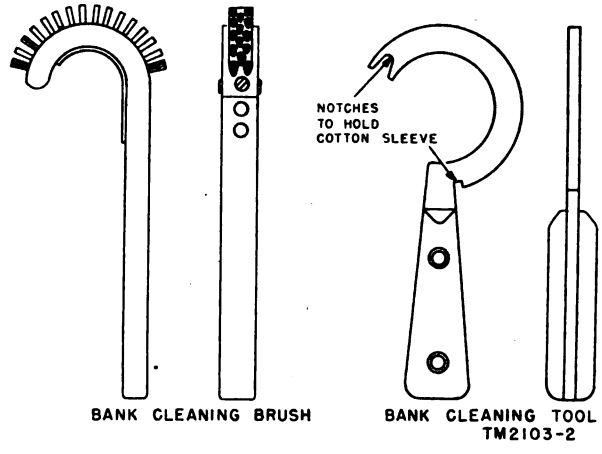


Figure 2. Switch bank contact cleaning tool and brush.

d. Where the equipment is operating under normal conditions (excessive dust and gritty dirt not present), impregnate the cotton sleeving with a small amount of instrument oil (P–38) (table V). The oil in the sleeving assists in removing gummy dust and dirt from the contacts. The very thin film of oil left on the contacts after cleaning and polishing provides smoother switch operation and lengthens the life of the wipers.

e. To prepare oiled sleeving for cleaning and polishing, cut the cotton sleeving in the required lengths. Distribute 3 to 9 dips (par. 20*a*) of instrument oil (P–38), using a No. 6 camel's-hair brush, over both sides of the cotton sleeving. Allow the oil to spread evenly over the sleeving. Slide the oiled sleeving on the blade and fasten as outlined in *b* above.

f. Check the switch banks for loose holding nuts

and collars, damaged insulators and contacts, and alinement with the switch frame.

15. Switch Bank Contact Wipers (figs. 21, 38, 40, 42, 95, and 96)

Examine the contact wipers carefully each time routine switch inspections are made. Check the following:

a. Inspect the tips of the bank contact wipers (fig. 40) for wear. Open the wiper tips slightly with an orange stick. Inspect the inside surface of the tips for wear, using a dental mirror. Replace the wiper if the leading edges of the tips are worn thin or becoming feathery. Readjust the wiper tip spacings if required (par. 49).

b. Inspect the tips of the top (control) bank contact wiper (fig. 21) for separation. On 100-point switches the tips should not be separated from each other. On 200-point switches, the control bank (fig. 41) has an upper and lower set of contacts and the wiper tips are insulated from each other. In this case, the control wiper tips must meet the requirements of the bottom (line) bank contact wipers, which are constructed in the same manner.

c. Inspect the tips of the bottom (line) bank contact wipers for separation. The tips of the line wipers should not touch, but should have a normal separation of 0.015 inch, or approximately the same as the thickness of the insulator between the bank contacts.

d. See that the wiper springs (figs. 38 and 40) are not bent, and are at a 90° angle with the switch shaft. Both wiper tips must deflect when the wiper is advanced over a bank contact. Test the operation of the wipers by operating the switch by hand. Check the wipers at three positions on the bank—at the first, fifth, and tenth contacts. Follow the adjustment procedure given in paragraph 49.

e. Inspect each wiper cord (figs. 21 and 95) for signs of damaged insulation or short-circuited terminals. Check the wiper cords for interference with the wiper assembly at all vertical and rotary steps of the shaft. On switches having a vertical bank and wiper, make sure that the wiper cords are properly dressed and secured so that no interference is caused to the vertical wiper and bank during vertical and rotary movement of the switch shaft. Check to make sure that the proper contact wiper has been used if replacement has been made. Use wipers equipped with cord holders for switches having a vertical wiper and bank assembly (fig. 95). If wipers with cord holders are not available and another type is used, see that the cords are properly laced with linen twine, and tied to the wipers (fig. 96).

16. Rotary Stepping Switches (25-point)

Perform the following PM routines on 25-point rotary stepping switches (fig. 46). This type of switch is used as the distributor switch on linefinder shelves, is also used in the howler, and is sometimes used as a lineswitch or trunk-selecting switch. Refer to paragraph 51 for the method of cleaning and adjusting 25-point rotary stepping switches.

a. Remove the cover, and clean and inspect the rotary magnet assemblies. Brush away any loose dust and dirt. Inspect the terminal lugs for loose or poorly soldered connections.

b. Clean and inspect the interrupter contact and bank contact assemblies.

c. Clean the switch bank contacts with either clean cloth or chamois stretched over the end of a thin hardwood stick. A drop of instrument oil (P–38) placed on the cloth or chamois will aid in removing dust or dirt from gummy contacts.

Caution: Avoid bending contacts, wipers, or brush springs while cleaning the contacts.

d. Lift the rotary pawl. Rotate the wiper assembly by hand, making sure it turns freely. Lubricate if required (par. 22 and fig. 5).

e. Operate the rotary armature (fig. 47) by hand. Wipers should advance one contact for each stroke of the armature, centering on the contact at the end of the stroke. If operation is faulty, adjust as outlined in paragraph 51. Replace the cover.

17. Minor Switches (fig. 48)

Perform the following PM routines on minor switches (10-point rotary stepping switches) commonly used in the 200-point test connector. Refer to paragraph 52 for the method of cleaning and adjusting minor switches.

a. Clean and inspect the switch contact assembly.

b. Brush dust and dirt from the coils and frame.

c. Inspect bank contacts. Remove the contact wiper assembly before cleaning the bank contacts. Clean the bank contacts with either clean cloth or chamois stretched over the end of a thin hardwood stick.

d. Replace the wiper assembly if removed. It should ride smoothly over the bank contacts without

snagging or sticking. Check the operation of the wiper by operating it across the contacts by hand.

e. Lubricate the wiper assembly shaft if required. Apply 1 drop of instrument oil (P–38) to the upper end of the shaft. Lubricate minor switches as outlined in paragraph 23.

f. Check the rotary stepping mechanism by operating the rotary armature by hand. Advance the wipers through all 10 rotary positions. The holding detent assembly should maintain the wiper in the center of the bank contact in each position. Press release armature. The wiper assembly should return smoothly to its normal position.

g. When normal operation cannot be obtained, adjust the minor switch in accordance with the instructions in paragraph 52.

18. Group Relays, Line Relays, and Other Relay Assemblies

Perform the following PM inspection routines on relay assemblies such as the linefinder group relays, interoffice pulse repeaters, line relays, attendant's switchboard relay racks, power board supervisory relays, and other relay equipments.

a. Remove the cover and inspect the relay assembly for the presence of dust and dirt. If necessary, brush dirt from relay coils, capacitors, and rectifiers. Hold a vacuum cleaner hose (if available) under the item being cleaned to prevent the dust and dirt from falling on adjacent equipment.

b. Clean the pole pieces and armature residuals by inserting a strip of bond paper between the pole piece and the armature. Operate the armature by hand, applying a slight pressure and at the same time withdrawing the bond paper. Repeat this operation until the bond paper comes out clean. Clean the relay contacts with a contact burnisher (WECo 265C).

c. Inspect relays for loose coils or mountings. Inspect all visible wiring for poorly soldered or loose connections.

d. Inspect relay contact assemblies for corroded or pitted contacts. Clean the contacts if required (par. 57).

e. Operate the relay armatures by hand, making sure that all contacts make and break properly, and with perceptible overtravel on either operation.

f. Inspect relay armatures for loose locknuts on residual screws.

19. Preventive Maintenance Checklist

Make a PM checklist for step-by-step dial central office equipment. Use DAAGO Form 11-207, 1 Mar 50 Routine Progress Record (par. 38). List equipment by groups or shelves and indicate proper time interval. Change routines if operating conditions make shorter intervals desirable.

Table IV. Preventive Maintenance Checklist

Item No.	Item routine	Par.	Interval	Date performed	Next inspection	Initials
1	Batteries	11	Daily			
2	Ringing machine	10	do			
3	Motor generator	10	do			
4	Power board circuits	10	do			
5	Alarms and supervisory signals	10	do			
6	CDF (MDF) protectors	12	do			
7	General cleaning	9	do			
8	Linefinder shelf	13	Monthly			
9	Connector shelf	13	do			
10	Selector shelf	13	do			
11	Switch contact banks	14	do			
12	Miscellaneous shelf	18	do			
13	Relay racks	18	do			
14	Trunk circuit equipment	18	Weekly			
15	Test desk and attendant's switchboard	18	Monthly			

Section III. LUBRICATION

20. General

Equipment used in step-by-step dial central offices does not require extensive and frequent lubrication. However, certain periodic lubrication is necessary for successful operation and economic maintenance of the equipment. The purpose of lubrication is to provide

a film of lubricant between fixed and moving surfaces to reduce friction and wear. Use only enough lubricant to provide the required film. Avoid excessive lubrication. Remove any excess lubricant by wiping.

a. DEFINITIONS. Three terms used in expressing the amount of oil to be used in the lubrication of step-by-step dial central office equipment are defined as follows:

(1) A *drop* of oil is the amount of oil released from the end of a bare tinned copper #22 B & S wire, after the wire has been dipped one-half inch into the oil and then quickly withdrawn.

(2) A *dip* of oil is the amount of oil retained in the bristles of a No. 6 camel's-hair brush or camel's-hair brush TL–72 after the brush has been dipped three-eighths inch into the oil, and then drawn across the edge of the container to remove the surplus oil. There should not be enough oil remaining in the bristles to form a drop at the end of the brush.

(3) A *small quantity* of oil is the amount of oil retained on a strip of paper or thin fiber after being immersed in the oil, withdrawn, and the free oil removed by wiping. Oiled strips of paper or thin fiber are used for lubricating wiper tips and similar contact brushes.

b. CLEANING. Clean bearings and exposed bearing surfaces, switch shafts and accessible moving parts before lubrication. Do not place additional lubricant containing graphite (graphited lubricating oil) (table V) on bearing surfaces that are already covered with graphite. In this case, apply a small amount of instrument oil (P–38) (table V). If the bearing surface is not sufficiently covered with graphite, or if the graphite is caked or gritty, thoroughly clean the surface and relubricate the bearing. Operate switches or other moving apparatus a few times after lubrication to distribute the lubricant thoroughly and to work it into the bearings. Always remove any excess lubricant by wiping.

c. RECOMMENDED LUBRICANTS FOR STEP-BY-STEP DIAL CENTRAL OFFICE EQUIPMENT. The following table lists the lubricants required for servicing step-by-step dial central office equipment:

Table V. Recommended Lubricants

Product symbol	Standard nomencature	Specification for Signal Corps stock No.
PL–Special	Oil, lubricating, preservative, special	U.S. Army spec. 2–120 JAN–L–644.
OCW	Oil, clock and watch	U.S. Army spec. No. 2–47B.
P–38	Oil, instrument ...	Sig C stock No. 6G-1398.7
	Oil, lubricating, graphited	Auto Elec Grade A, spec. 5232 Sig C stock No. 6G1837.
OE–10	Oil, engine	U.S. Army spec. No. 2–104B (Amend. 5).
GL	Grease, lubricating, special	U.S. Army spec. No. 2–134.

21. Two-motion Stepping Switch (figs. 3 and 4)

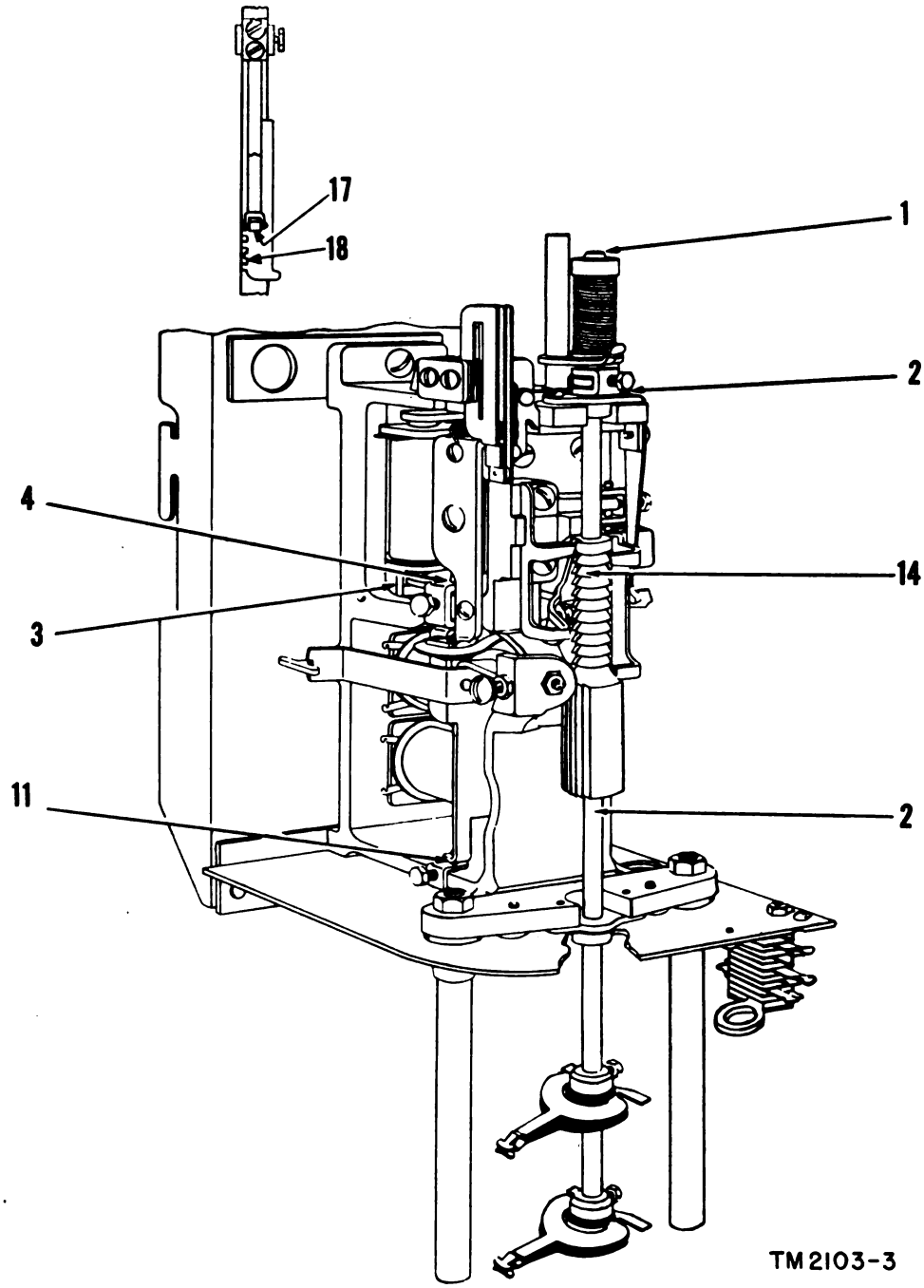
All parts of two-motion stepping switches should be lubricated every 6 months with the exception of the switch shaft hub (vertical and rotary ratchets), which should be lubricated whenever required as determined by inspection. This period of lubrication may be shortened or lengthened to meet abnormal operating conditions. Apply the specified lubricants, in the amounts specified, to the following parts of two-motion stepping switches:

a. Apply 1 dip of instrument oil (P–38) (table V) to the shaft extension sleeve ((1) of fig. 3) just above the shaft spring bracket.

b. Apply 3 dips of instrument oil (P–38) to each upper part of the two bearing surfaces of the switch shaft ((2) of fig. 3) with the shaft raised to its highest vertical position. Space the dips approximately 120° apart on the shaft circumference. Allow the shaft to remain in the raised position for at least 5 minutes before lowering.

c. Distribute 1 dip of instrument oil (P–38) to the following points in the order listed: the vertical armature bearing pin (fig. 3 and (3) of fig. 4) at the outer surfaces of the armature bearing bracket and the bearing pin; the upper rotary armature bearing pin ((4) of fig. 3) at the upper surface of the bearing lug; the normal post ((5) of fig. 4) along the surfaces which may be engaged by the shaft spring bracket; the off-normal lever ((6) of fig. 4) applied above the rivet at the angle formed by the off-normal lever and the shaft spring bracket.

d. Apply 1 dip of instrument oil (P–38) (table V) to the vertical pawl ((7) of fig. 4) between the vertical pawl bearing lugs.

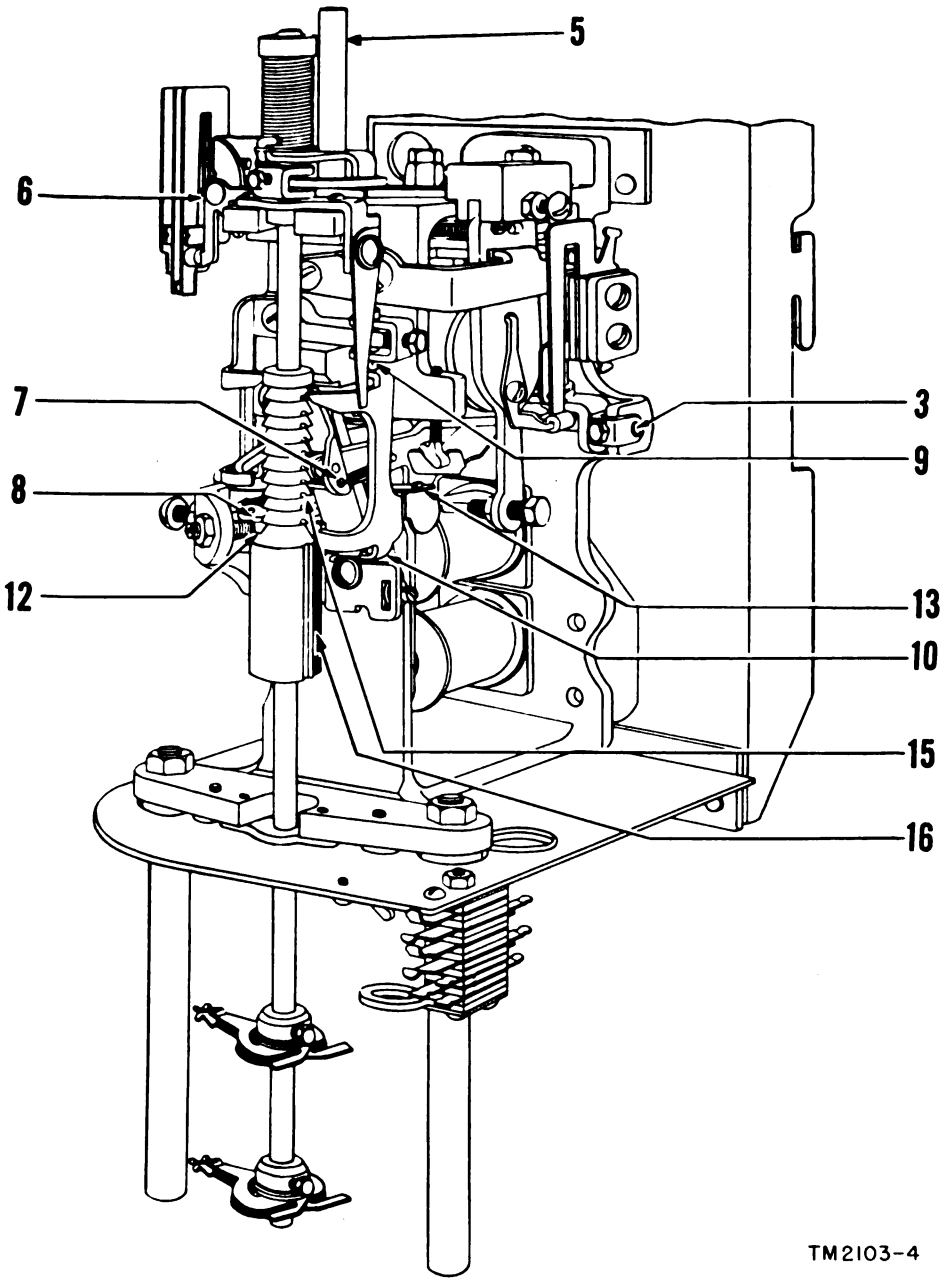


1. Shaft spring (extension sleeve).
2. Shaft switch bearing surfaces.
3. Vertical armature bearing pin.
4. Upper rotary armature bearing pin.
11. Lower rotary armature bearing pin.
14. Six upper teeth of vertical ratchet.
17. Shaft spring roller bearings.
18. Cam operating teeth.

Figure 3. Lubrication chart for two-motion stepping switch, left side.

e. Apply 1 dip of instrument oil (P–38) to the rotary pawl ((8) of fig. 4) between the pawl bearing lugs and the end of the rotary armature.

f. Distribute 1 dip of instrument oil (P–38) to the following points in the order listed: the double detent bearing pin ((9) of fig. 4), just above the upper bearing bracket of the double detent; the double detent bearing pin ((10) of fig. 4), at the angle formed by the pin and the upper surface of the lower bearing; the lower rotary armature bearing pin ((11) of fig. 3), on the upper surface of the bearing bracket; the tip of the rotary pawl guide ((12) of



3. Vertical armature bearing pin.
5. Normal post.
6. Off-normal lever.
7. Vertical pawl.
8. Rotary pawl.
9. Double detent bearing pin.
10. Double detent bearing pin.
12. Rotary pawl guide.
13. Double detent release link tooth.
15. Vertical ratchet teeth.
16. Rotary ratchet teeth.

Figure 4. Lubrication chart for two-motion stepping switch, right side.

fig. 4) ; the tip of the double detent release link tooth ((13) of fig. 4).

g. Apply 1 dip of graphited lubricating oil (table V) to the six upper teeth of the vertical ratchet ((14) of fig. 3), at the points where the vertical pawl engages the vertical ratchet teeth.

h. Apply 1 dip of graphited lubricating oil to all the teeth in the vertical ratchet ((15) of fig. 4) from the stationary detent groove to the notches on which the vertical tip of the double detent rides.

i. Apply 1 dip of graphited lubricating oil to all teeth in the rotary ratchet ((16) of fig. 4), from the top to a point approximately one-fourth inch from the bottom.

j. Distribute 1 dip of instrument oil (P–38) to the following points (on switches equipped with multi-level normal post cam springs) in the order listed: the shaft spring roller bearings ((17) of fig. 3); the operating teeth on the cam ((18) of fig. 3), on the edge contacted by the roller.

22. Rotary Stepping Switch (25-point) (fig. 5)

a. Lubricate rotary stepping switches at the end of the first month after installation, at the end of the third month, at the end of the sixth month, and every 6 months thereafter under normal operating conditions. The 6-month period of lubrication may be shortened or lengthened to meet other than normal operating conditions.

b. When lubrication is required, apply the specified lubricants in the amount specified to the following parts of 25-point rotary stepping switches:

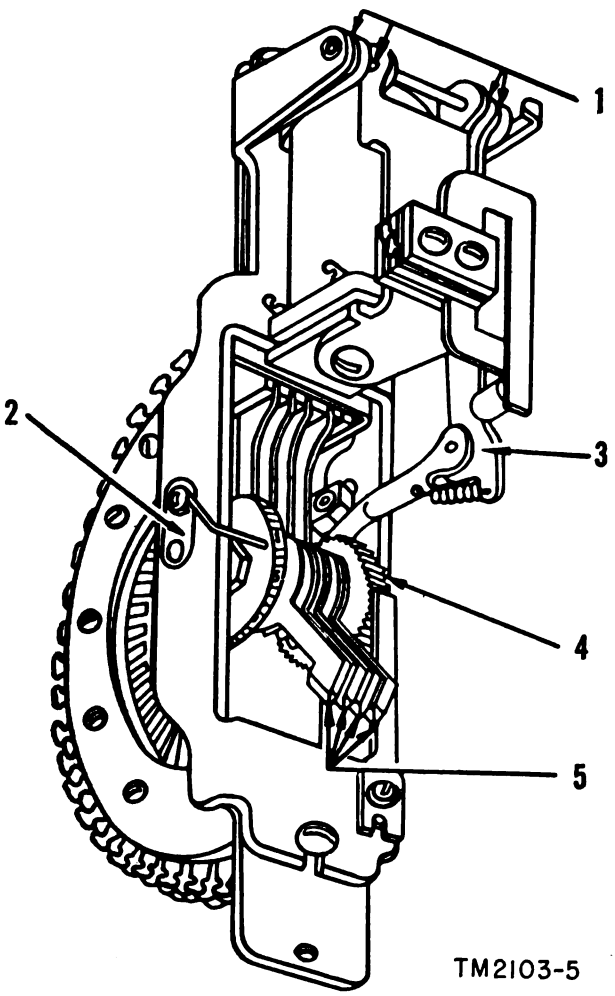
(1) Apply 4 drops of instrument oil (P–38) (table V) to the armature bearings ((1) of fig. 5).

(2) Lubrication of the bearing pin during manufacture should be sufficient for the life of the switch. If excessive friction is noted in the switch, lubricate by applying 1 drop of oil (OE–10) (table V) between the switch frame and the wiper assembly shaft at each end ((2) of fig. 5).

(3) Apply 1 drop of instrument oil (P–38) to the rotary pawl bearing ((3) of fig. 5).

(4) Distribute 2 dips of graphited lubricating oil (table V) on the ratchet gear teeth ((4) of fig. 5). Rotate the wiper assembly by hand while applying.

(5) Apply 1 dip of oil (OCW) (table V), distributed between the 4 pairs of wiper tips ((5) of fig. 5), and on both ends. Rotate the wiper assembly after applying the oil to distribute the lubricant on the switch bank contacts.



1. Armature bearings.
2. Switch frame.
3. Rotary pawl bearing.
4. Ratchet gear teeth.
5. Wiper tips.

Figure 5. Lubrication chart for 25-point rotary stepping switch.

23. Minor Switch (fig. 6)

a. Lubricate minor switches at the end of the first month after installation, at the end of the third month, at the end of the sixth month, and every 6 months thereafter under normal operating conditions. The 6-month period of lubrication may be shortened or lengthened to meet other than normal operating conditions.

b. When lubrication is required, apply the specified lubricants, in the amount specified, to the following parts of minor switches:

(1) Apply 1 dip of instrument oil (P–38) (table V) to the wiper assembly bearing ((1) of fig. 6) through the slot in the wiper shaft.

(2) Apply 1 dip of instrument oil (P–38) to the rotary pawl bearing ((2) of fig. 6).

(3) Apply 1 dip of instrument oil (P–38) to the rotary armature spring bearing surface ((3) of fig. 6) on the frame.

(4) Apply 1 dip of instrument oil (P–38) to the rotary pawl guide arm bearing surface ((4) of fig. 6) on the frame.

(5) Apply 1 dip of instrument oil (P–38) to the rotary pawl stop ((5) of fig. 6) at the point where it is engaged by the pawl.

(6) Apply 1 dip of instrument oil (P–38) to

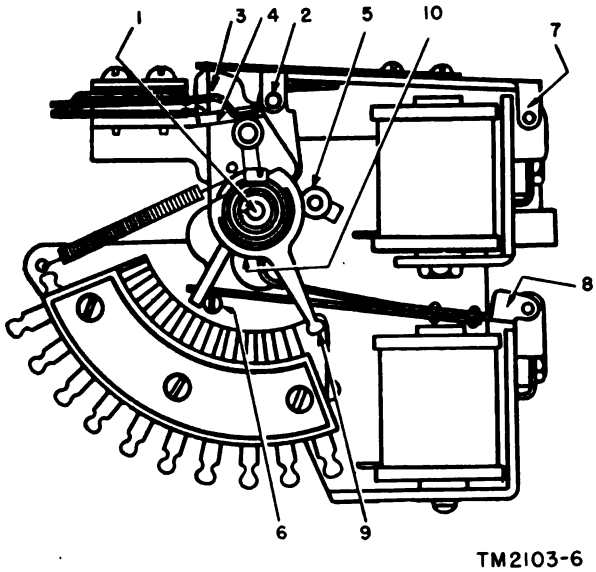
the release armature spring bearing surface ((6) of fig. 6) on the normal stop pin.

(7) Distribute 1 dip of instrument oil (P–38) on the rotary armature bearing pin ((7) of fig. 6) where it touches the bearing yoke.

(8) Distribute 1 dip of instrument oil (P–38) on the release armature bearing pin ((8) of fig. 6) where it touches the bearing yoke.

(9) Apply a small quantity of instrument oil (P–38) to the wiper tips ((9) of fig. 6).

(10) Distribute one dip of graphited lubricating oil (table V) on the rotary ratchet teeth ((10) of fig. 6).



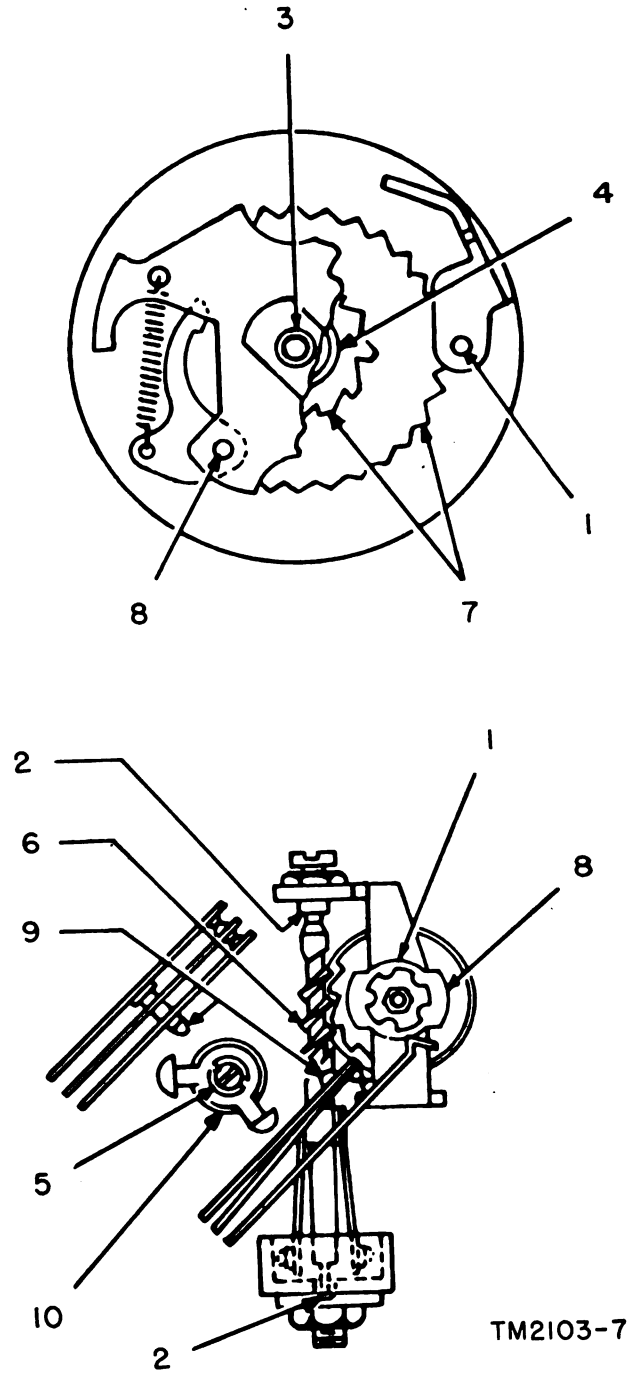
1. Wiper assembly bearing.
2. Rotary pawl bearing.
3. Rotary armature spring bearing surface.
4. Rotary pawl guide arm bearing surface.
5. Rotary pawl stop.
6. Release armature spring bearing surface.
7. Rotary armature bearing pin.
8. Release armature bearing pin.
9. Wiper tips.
10. Rotary ratchet teeth.

Figure 6. Lubrication chart for minor switch.

24. Dial (fig. 7)

a. Remove the screws holding the dial in the dial mounting and lift out the dial. Inspect the dial for lack of lubrication. Observe its operation. Lubricate the dial only when necessary to provide smooth and positive mechanical operation. Lubrication once a year should be sufficient.

b. Prepare the dial for lubrication by removing the dial escutcheon assembly and the finger plate mounting screw. Remove the finger plate.



1. Worm wheel bearings and shaft.
2. Governor shaft bearings.
3. Dial shaft bearings.
4. Main wheel bearing.
5. Main bearing (exposed portion).
6. Governor shaft worm.
7. Ratchet teeth.
8. Cam, cam shaft, and pawl bearing.
9. Shunt and pulse springs.
10. Spring coils.

Figure 7. Lubrication chart for dial.

c. Lubricate the dial (fig. 7) by applying oil (OCW) (table V) in the amount specified, to the following parts:

(1) Distribute 1 dip of oil to the worm wheel shaft bearings ((1) of fig. 7) and brush a small amount of oil over the surface of the worm wheel shaft from the worm wheel to the finger stop bearing, for rust protection.

(2) Distribute 1 dip of oil on the governor shaft bearings ((2) of fig. 7).

(3) Place 1 drop of oil in the finger plate mounting screw hole to lubricate the dial shaft bearings ((3) of fig. 7).

(4) Apply 1 dip of oil to the main wheel bearing ((4) of fig. 7).

(5) Cover the exposed portion of the main bearing ((5) of fig. 7) on the governor side of the mounting plate with 1 dip of oil for rust protection (with the spring removed).

(6) Apply 1 dip of oil to the governor shaft worm ((6) or fig. 7). Brush a small amount of oil on the shaft under the governor wings for rust protection.

d. Lubricate the following parts of the dial by applying instrument oil (P–38) (table V) in the amount specified:

(1) Brush 1 dip of oil evenly over the ratchet teeth ((7) of fig. 7). Brush 1 dip of oil evenly over the gear teeth.

(2) Distribute 1 dip of oil on the edge of the cam and threaded portion of cam shaft ((8) of fig. 7) and to the pawl bearing ((8) of fig. 7).

(3) Distribute 1 dip of oil on the fiber buffers of the shunt and pulse springs ((9) of fig. 7). Allow the oil to stand for a short time, and then remove surplus oil.

Caution: Do not apply oil to the rubber buffers.

(4) Distribute one dip of oil between the spring coils ((10) of fig. 7) for rust protection.

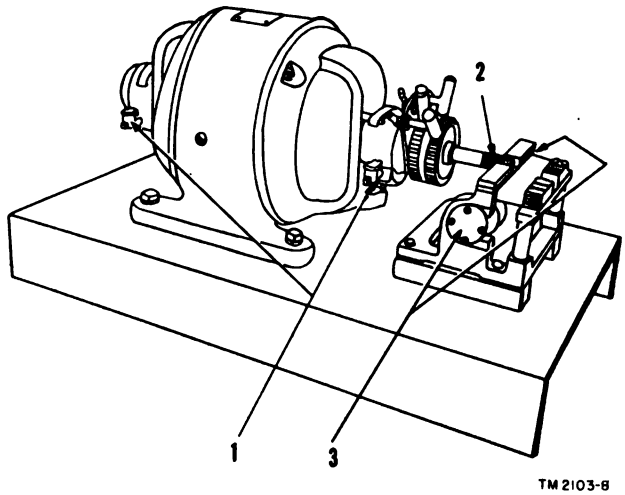
e. Remove any excess lubricant from surfaces when lubrication is completed.

25. Dynamotor Ringing Machine Lubrication (fig. 8)

a. The dynamotor ringing machine used in typical step-by-step dial central offices has sleeve-type bronze bearings; its bearing housings are packed with wool. The wool is thoroughly oiled before the machine is shipped from the factory. The bearings do not require oiling until after 6 months of operation (or 1 yr. in storage), and under normal operating conditions require oiling once a year thereafter. Never lubricate the dynamotor ringing machine more often than every 6 months.

(1) Lubricate the dynamotor ringing machine by giving the oil cups ((1) of fig. 8) 1 filling of oil (OE–10) (table V). The oil feeds slowly into the bearing housing and is absorbed by the wool packing. No oil should remain visible in the oil cups. Visible oil indicates over-oiling. Do not pour the oil into the opening in the top of the bearing housing. This causes overlubrication, resulting in oil-soaked motor windings.

(2) Do not lubricate the composition fiber gear and the steel worm ((2) of fig. 8) driving the interrupter shaft because they have already been lubricated by the manufacturer. Further lubrication is not recommended by the manufacturer. If the gear becomes noisy, apply a small amount of graphited lubricating oil (table V).



1. Oil cups. 2. Composition fiber gear and steel worm.
3. Two sealed bearings on the ends of interrupter shaft.

Figure 8. Lubrication chart for dynamotor ringing machine.

(3) Do not lubricate the two sealed bearings ((3) of fig. 8) on the ends of the interrupter shaft. They are packed with grease at the factory and require no additional lubrication.

b. In dial central offices using older types of ringing dynamotors, lubricate according to the manufacturer's instructions. Machines having oil-ring type

bearings require that the oil cups be kept about half filled with oil at all times; check the oil level weekly.

26. Diverter-pole Motor Generator (fig. 9)

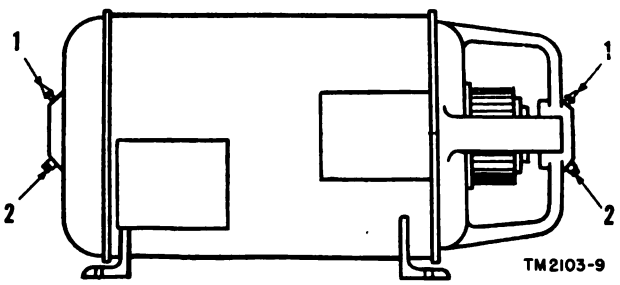
a. The ball bearings of the diverter-pole motor generators are thoroughly lubricated before shipment is made from the factory. Additional lubrication should not be required until after 2 years of operation (or 1 yr. of storage), and every 2 years thereafter.

b. Make monthly inspections to be sure that the bearings are running quietly and without overheating. If inspection reveals hot or noisy bearings, lubricate as outlined in *c* below.

c. When lubrication of the motor generators (fig. 9) is required, apply the specified lubricant in the amount specified, to the following parts:

(1) Remove the grease fittings ((1) of fig. 9) and the bearing housing drain plugs ((2) of fig. 9). With a clean orange stick or similar instrument free the openings of any hardened grease.

(2) Place a suitable receptacle under the drain holes. Place the motor generator in operation. Pour a small amount of light flushing oil in the holes from which the grease fittings have been removed. Allow the oil to drain from the bearing housing. Repeat this process until the flushing oil drained from the bearing housing is clean.



1. Grease fittings. 2. Bearing housing drain plugs.

Figure 9. Lubrication chart for diverter-pole motor generator.

(3) When the old lubricant is not easily removed from the bearings, leave the drain plug in the bearing housing, and pour in a small amount of flushing oil. Operate the machine with no load for a few minutes to flush all parts of the bearing housing thoroughly; then stop the machine, remove the drain plug, and drain the bearing housing. Repeat this process until the flushing oil drained from the bearing housing is clean.

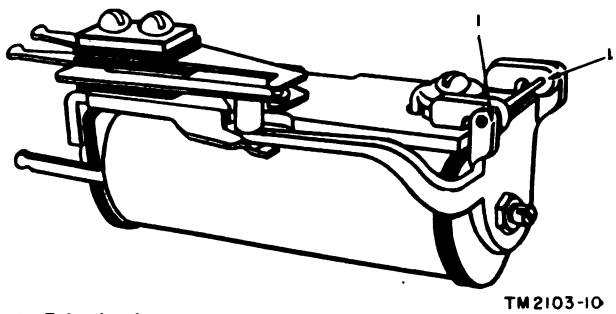
(4) After completing the flushing and draining, as outlined in (1) through (3) above, replace the drain plug. Fill the bearing housing about one-third full of light machine oil. Run the machine under no load for one-half hour. Remove the drain plug and and allow the machine oil to drain completely out of the bearing and bearing housing.

(5) Replace the grease fittings if used. On machines using grease cups or plugs, do not replace the grease cups or plugs. *Do not replace the drain plugs.* Use the grease gun supplied by the manufacturer, and fill the bearing housings with grease (GL) (table V). Never add grease with a grease gun unless the drain plug is removed. With the machine running, force grease slowly into the bearing housings. Add grease until it begins to be expelled from the drain hole. Do not overfill. The housing should be about one-half full. Keep the machine running for a few minutes to expel excess grease.

(6) Stop the machine and replace the drain plugs (also the grease cups or plugs if used). Wipe off any traces of the flushing oil on the shaft next to the bearing housings.

27. Other Parts Requiring Lubrication

Armature-type relays usually are not lubricated. In case of extremely heavy use, however, inspect and lubricate if necessary. Never lubricate relays exposed to grit or dust. Lubrication under such conditions increases rather than retards bearing wear, and may also cause sticking or nonoperation of the armature. When lubrication is indicated, apply oil (PL-Special) (table V) to the relay bearings ((1) of fig. 10). One dip of oil should be sufficient to lubricate the bearings of six relays.



1. Relay bearings.

Figure 10. Lubrication chart for relays.

Section IV. ROUTINE TESTING

28. Routine Testing Procedure

a. Step-by-step dial central office switching equipment must be tested in scheduled routines to detect equipment faults before serious service interruptions result. Special equipment is provided in step-by-step dial central offices for routine testing (sometimes called *routining*). The power equipment is tested by means of the indicating meters on the power board.

b. The wire chief determines the frequency of routine tests, depending on operating conditions. Enter the results of routine tests on the DAAGO Form 11-207 (Routine Progress Record).

c. The following equipment is used in typical step-by-step dial central offices for routine tests:

(1) *Connector routine test set (Auto Elec H–45987–1)* (fig. 13). This test set is used on regular 100-point or 200-point connectors, PBX (trunk-hunting) connectors and reverting-call switches. Refer to TM 11–2113 for complete operating instructions for routine tests, and the theory of operation of the connector routine test set.

(2) *Stepping-switch test set (Auto Elec H–55165–B)* (fig. 14). This test set, sometimes called *impulse testing machine, test-pulse machine, varying machine, interrupter machine,* and *dial pulse generator* by the manufacturer, is used to test the pulse repeaters, the vertical stepping action of selectors, and the vertical and rotary stepping action of connectors. TM 11–2114 covers the theory of operation and operating procedure for routine tests with the stepping-switch test set.

(3) *Test telephone handset (Auto Elec L–965–AO)* (figs. 11 and 12). This handset type test telephone is used for testing step-by-step dial central office switching equipments which are provided with test jacks. The test telephone handset has a dial, a series capacitor, and a 1,200-ohm resistor. The capacitor permits monitoring in a circuit without disturbing the connection. A push-switch, marked C on the test telephone handset, normally short-circuits the capacitor (fig. 11). The capacitor is placed in the circuit by holding push-switch C operated. The resistor normally is short-circuited by a push-switch, marked R. Operating push-switch R places the resistor in series with the line, and simulates the extreme limit of loop resistance of a substation line while dialing during tests. The test telephone handset cord terminates in a special plug which mates with the terminals of the test jack on the switching equipment. plugging in the test telephone handset closes the loop circuit to the equipment, causing it to be busy to any other calls and preparing it for dialing. Operating push-switch C opens the loop circuit, permitting the equipment to release. To monitor on equipment that is busy, push-switch C should be held operated. Use the test telephone handset to localize trouble in switching equipment. It may also be used for routine testing, but the special test sets supplied for this purpose give more complete checks and should be used whenever groups of switches are to be checked. Refer to TM 11–2111 for further details concerning the test telephone handset.

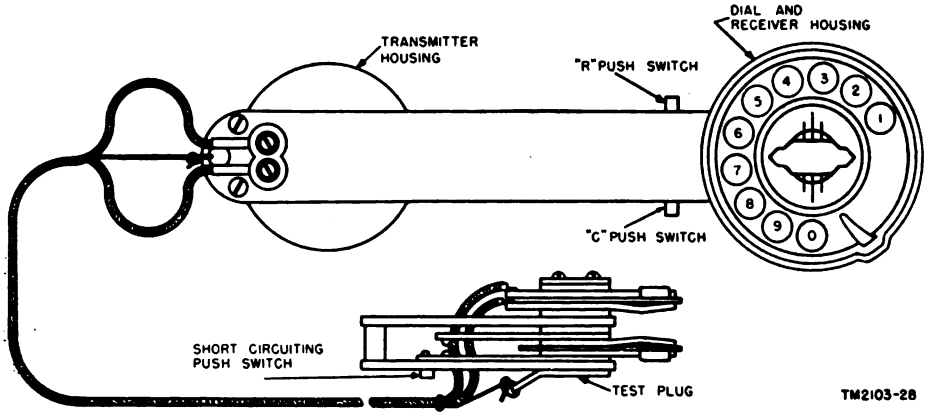


Figure 11. Test telephone handset.

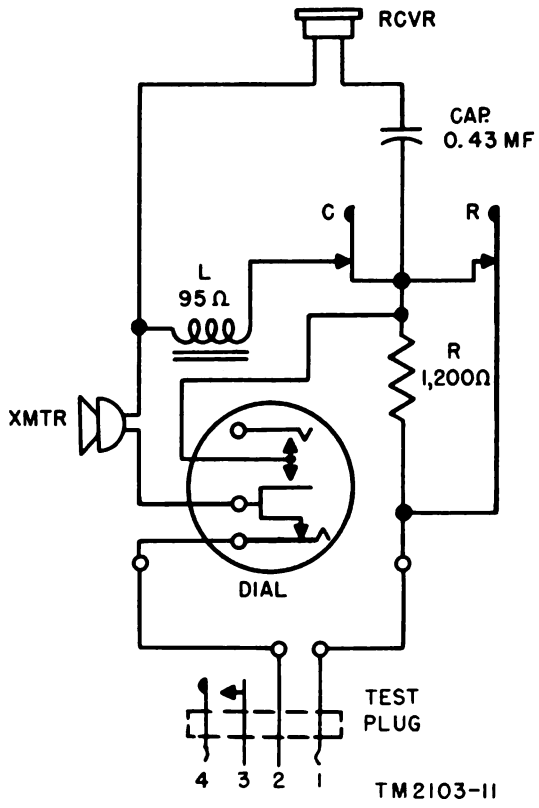


Figure 12. Test telephone handset, schematic diagram.

d. Operate the busying switch on units showing faulty operation to take them out of service. Operate this switch by turning the lever 90°, so that the handle points outward. Complete the routine tests, record the defective units, and make repairs at the earliest possible time. Most of the faults can be corrected by adjustment (pars. 46 through 50). When repairs are required, follow the procedures indicated.

29. Ringing, Tone, and Interrupter Circuit Tests

The ringing machine control circuit is designed so that when ringing machine No. 1 is used, ringing machine No. 2 acts as a stand-by which is automatically switched into the circuit if ringing machine No. 1 fails. The ringing machines generate ringing current and tones, and have interrupters for automatic ringing and delayed alarms.

a. Test the automatic switching of the ringing machines daily at the power board. Operate to the OFF position the manual starting switch which controls ringing machine No. 1. Failure of ringing current from ringing machine No. 1 should cause the ringing machine transfer relays to operate, switching the tone, interrupter, and alarm time delay circuits to ringing machine No. 2, which automatically starts at the same time. The interruption of the ringing current causes the power board alarm bell to sound and the visual signals to operate momentarily until ringing machine No. 2 delivers ringing current. The current from ringing machine No. 2 cuts off the alarm signals with the exception of the white RM1 OFF lamp on the miscellaneous lamp and switch panel. This lamp remains on until ringing machine No. 1 is put back into the circuit. Should ringing machine No. 2 fail to deliver ringing current, the alarm circuits operate. Refer to TM 11–2108 for a detailed explanation of the functioning of the automatic switching and alarm circuits.

b. Inspect the ringing generator interrupter relays on the power board weekly. Since these relays operate constantly, check them to make sure that they are responding to the opening and closing of their control circuits by the five sets of interrupter contacts on the ringing machine assembly. Clean and adjust the ringing generator interrupter relays if necessary (pars. 54 and 55).

c. Check the ringing and tone circuits daily.

30. Supervisory Signal Tests

Test the supervisory signal system daily, if practical, to assure that the switchman will receive prompt notice of any failure of step-by-step dial central office equipment. Refer to TM 11–2108 for a complete description of the alarm circuits.

a. Fuse Alarms.

(1) Test the main battery fuse alarm circuit by connecting a test receiver or test lamp (fig. 15) between the left end of the alarm fuse (located just below the main fuse) and the fuse alarm stud (approximately under the center of the alarm fuse). The red fuse alarm lamp on the panel below the alarm fuse should light, and the alarm bell should sound.

(2) Test the distributing fuse alarm circuit by connecting a test receiver or test lamp (fig. 15) between the upper bus-bar terminal of any of the distributing alarm fuses and the small alarm bus-bar directly under the alarm fuses. The red alarm lamp on the left side of the fuse panel should light, and the alarm bell should ring.

(3) Test the fuse alarm circuit for the supervisory fuse panel by connecting a test receiver or test lamp (fig. 15) between the

upper bus-bar fuse terminal of any of the 3-amp (ampere) fuses and the fuse alarm bus-bar below the fuse terminal. The red fuse alarm lamp (upper one) on the left side of the fuse panel should light, and the alarm bell should ring. Short-circuit the upper terminal of any of the 1-ampere fuses on the same panel and the associated fuse alarm bus-bar. The lower red alarm lamp (on the left side of the panel) should light, and the alarm bell should ring.

(4) Follow the procedure outlined in (1) through (3) above to test the fuse alarm circuit for the attendant's switchboard and for the wire chief's test desk. The red alarm lamp on the left of the lamp panel 1–F should light, and the alarm bell should ring.

(5) Test the fuse alarm circuit of each of the power board signal group relays. The red bay lamp associated with that particular signal group should light, and the alarm buzzer should sound.

(6) Test the fuse alarm circuit of the motor-generator charging circuit by connecting between one terminal of the alarm fuse (at the left of the main fuse) and the fuse stud under the center of the alarm fuse. The red motor-generator fuse alarm lamp (MGFA) should light and the alarm bell should sound. Test the alarm circuits of both motor generators. This test also tests the fuse alarm circuit for the reverse current relay.

b. HIGH- AND LOW-VOLTAGE ALARM. Test the high-voltage alarm circuit by operating the armature of the high-voltage relay (HV) by hand. The white voltage alarm lamp (VOLT ALM) at the top of the panel should light, and the alarm bell should ring. Test the low-voltage alarm circuit by releasing the armature of relay LV. The white voltage alarm lamp (VOLT ALM) should then light and the alarm bell should ring.

c. END-CELL AND RECTIFIER ALARMS.

(1) Test the end-cell alarm and switching circuit by releasing the armature of the end-cell voltage switch (ECV). The white END CELL ALM lamp on the right side of the panel should light.

(2) Test the rectifier alarm circuit by throwing the rectifier switch to the OFF position. The red alarm lamp just below the switch should light.

d. RINGING MACHINE ALARM. Test the ringing machine alarm circuit by following the switching procedure described in paragraph *29a.*

e. DELAYED ALARMS. An alarm circuit with time delay is incorporated in the power circuit. It is composed of two sets of interrupters in the ringing machine and a chain of delay relays on the power board. The circuit is connected to the release signal relays on the linefinder, selector, and connector shelves.

(1) Test the linefinder delayed release alarm circuit on each linefinder shelf by raising a linefinder switch shaft. Hold it in the raised position until the delay alarm cycle is completed and the alarm buzzer sounds. Make sure that the green release lamp (RLS) (on the shelf on which the switch is mounted) lights, and that the red bay lamp lights.

(2) Test the delayed alarm circuit for linefinder starting and linefinder permanents (par. 43*c*) by manually operating the armature of relay C–3 on the group relay assembly. Hold it in the operated position until the delay cycle is completed and the power board alarm buzzer sounds. Make sure that the white START lamp (on the shelf on which the switch is mounted) lights, and that the red bay lamp also lights.

(3) Perform tests similar to those outlined in (1) and (2) above on the selector and connector shelves until all of the signal group alarm circuits have been tested. On the selector and connector shelves, the green release lamp (RLS) and the power board alarm buzzer operate in this delayed alarm test.

f. CDF ALARM. Test the CDF heat coil and protector alarm circuit by short-circuiting an inner terminal (line) or the alarm contact of a protector to ground. This should cause the white tell-tale lamp associated with the particular vertical frame to light. Repeat the test on all verticals.

g. SUPERVISORY SIGNAL LAMPS. The white supervisory lamp on each connector and selector shelf indicates that either the *calling* or the *called* party has not replaced the receiver on the hookswitch, or that some other trouble is holding the hookswitch operated.

(1) Test the selector supervisory lamp circuit

by manually operating relay A on one of the selectors on each shelf and observing that the supervisory lamp glows.

(2) Test the permanent supervisory lamp (PERM) on the connector signal panel by manually operating relay D on one of the connectors.

31. Linefinder Tests

a. Chain Circuit Test (daily).

(1) Short-circuit the top two group relay springs associated with group A of a linefinder unit. The idle linefinders in group A should step up to the fifth level and rotate to the eleventh position, and then release, in proper sequence. While the switches are stepping and rotating, watch for slow, uneven, or otherwise abnormal operation.

(2) Operate group A busy key and note that the idle linefinders in group B are selected, step to the tenth level, rotate to the eleventh position, and release, in proper sequence.

(3) Repeat steps (1) and (2) above, starting with group B of a linefinder unit to determine whether the equipment will transfer both ways. Perform this chain circuit test daily on all linefinder units in the exchange.

b. Operation Test (weekly).

(1) First, test group A of a linefinder unit, using the test telephone handset (figs. 11 and 12 and Auto Elec L–965–AO). Insert the test plug of the handset into the group relay test jack, with the push switch on top. This will cause one of the linefinders to select the test line, No. 29.

(2) Listen for dial tone, then dial the digit of a vacant level (par. 41*a*(6)) (any unused level as shown on the step-by-step dial central office schematic cabling diagram (figs. 100 and 101) furnished by the manufacturer). The dial tone should change to all-trunk busy tone.

(3) Operate push-switch C on the test telephone handset to release the linefinder.

(4) Release push-switch C, thus causing the next idle linefinder to select the test line (No. 29).

(5) Repeat steps (1) through (4) above until all linefinders of group A have been tested.

(6) Operate the group relay busy key in linefinders group A and proceed with the test on linefinders of group B.

(7) Restore the group relay busy key of linefinders group A.

(8) Make a similar test of linefinders of group B from the group B test jack, and transfer to linefinders group A to determine whether the equipment will transfer both ways. Perform this operation test weekly on all linefinders on the exchange.

Note. The test line number in linefinders group B is No. 99.

32. Connector Ringing, Talking, and Busy Tests (fig. 13)

Frequent routine tests of connector switches are essential. If one of the connectors does not perform all its functions properly it will cause serious service interruptions, since the same connector might be selected every time that it is the first choice for a selector searching for an idle connector in the group. Make daily tests with the connector routine test set (fig. 13 and Auto Elec H–45987–1). Refer to TM 11–2113 for more detailed information on this test set.

a. Preparation (fig. 13). Connect the ANS–48V plug of the connector routine test set (fig. 13) into test No. 199 jack on the test number panel mounted on one of the shelves in each connector bay. For 200-line connectors the test jack on the left of the strip is No. 199 and the jack at the right is No. 299. Test No. 199 on each connector in turn, inserting the test plug in its test jack and performing the following tests.

b. Busy Test (fig. 13). Dial test No. 199. The connector should make nine vertical and nine horizontal steps and switch through to the test number. The connector routine test set loop circuit has 1,200 ohms resistance, giving a critical test of the response of the stepping mechanism. Leave all lever switches (keys) on the connector routine test set at normal. When the connector has switched through to the test number, busy tone should be heard in the connector routine test set receiver (fig. 13). Release the connector by operating the RLS switch.

c. Ringing, Ring Cut-Off, and Talk Test (fig. 13). Operate the SHUNT switch on the connector routine test set (fig. 13) to remove busy tone from the test number, and again dial the test number. This combines a test of connector vertical and rotary stepping with a shunt leakage across the loop and permits test for idle line conditions. When the connector switches through to the test number, interrupted ringing current is sent to connector routine test set ringer

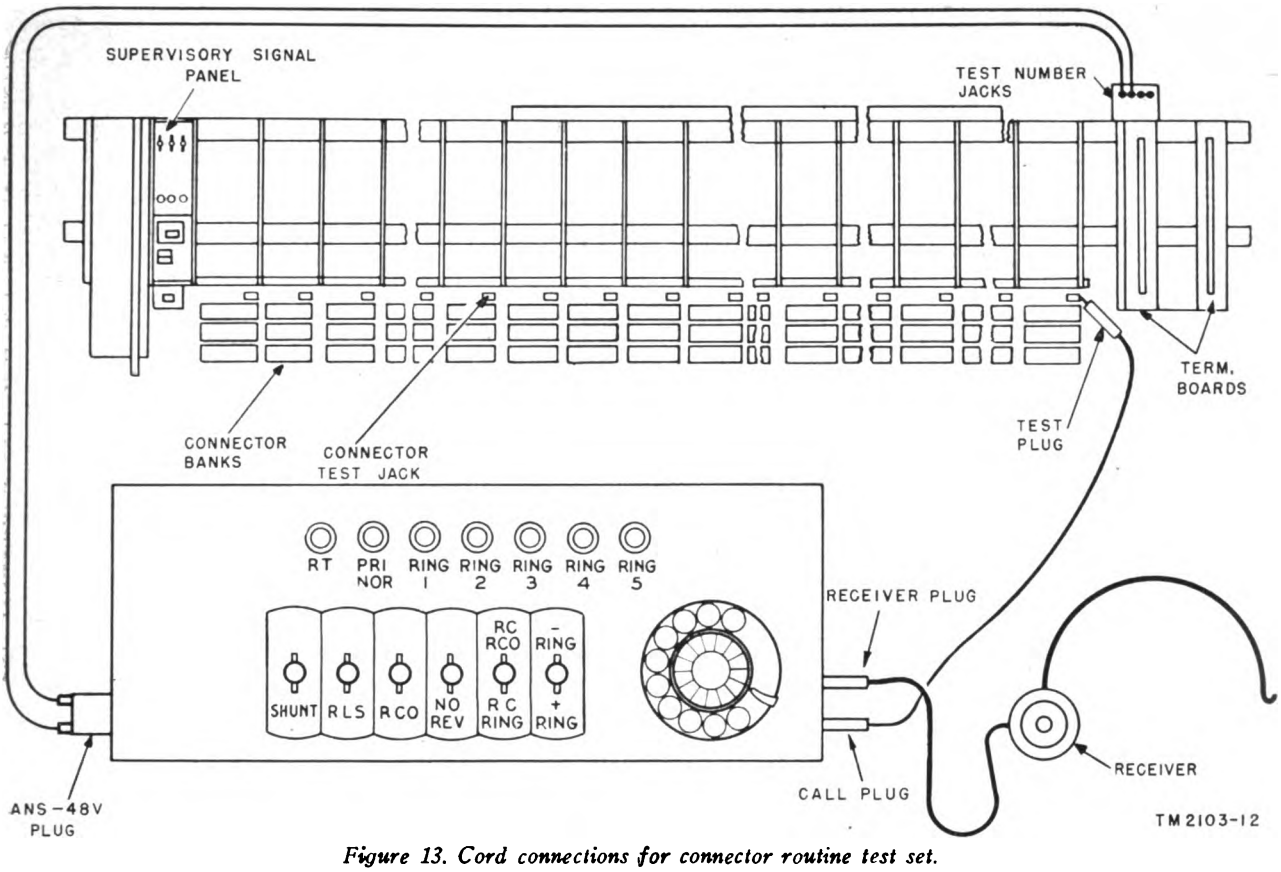


Figure 13. Cord connections for connector routine test set.

and ring-back tone is sent to the connector routine test set receiver. The ringer and ring-back tone should sound intermittently, and the primary normal lamp (PRI-NOR) on the connector routine test set should glow. If this does not occur, recheck the connector routine test set connections and make sure the proper test number has been dialed. If the ringing test is satisfactory, hold the ring cut-off switch (RCO) operated on the connector routine test set. This stops the ringing and the ring-back tone. The connector routine test set then transmits a buzzer tone through the connector to the connector routine test set receiver. Reception of the tone indicates that the ring cut-off and talking circuits of the connector are satisfactory. This test applies to connectors with reverse battery circuit, used in typical step-by-step dial central offices. For types of connectors without reverse battery in older step-by-step dial central offices, operate the no-reverse switch (NO REV) to make this test.

d. Bank Selection Test (fig. 13). With the ANS–48V plug of the connector routine still connected to test No. 199, dial No. 299. The ringer should not sound and ring-back tone should not be heard. This indicates that the bank selecting relay of the connector has functioned properly and has switched the bank contact wipers to the upper bank.

e. Release by Called Party Test (fig. 13). For connectors that are released by the called party, restore the RCO switch to its normal position. The connector should not release. Notice that the white PERM lamp on the supervisory signal panel glows. Again operate the RCO switch and note that the lamp does not glow. With the RCO switch operated, operate the RLS switch. The connector should not release, but the RLS TRK lamp on the connector routine test set should flash and the PERM lamp on the connector signal panel should glow. Restore the RCO switch, and the connector should now release. Return all switches to the normal position. Connect the test plug to the test jack of the next connector to be tested.

f. Trunk-Hunting (PBX) Connector Test. Trunk-hunting or PBX (private branch exchange) connectors are designed for connecting to trunks of PBX switchboards, or for ringing adjacent telephones in an office when the dialed telephone is busy. The trunks or telephones for this service are assigned numbers in sequence, and the connector searches over each number in the group until one is found not busy.

If all the numbers in the group are busy, busy tone is sent back at the last number in the trunk or line sequence. This type of connector has bank contact No. 90 assigned as test number, multiplied to test No. 199 on the nearest regular connector shelf. Bank contact No. 99 of trunk-hunting connectors is made busy. When testing trunk-hunting connectors, connect the ANS–48V plug of the test set to test No. 199 on the nearest regular connector shelf, connect the test plug to the test jack on one of the trunk-hunting connectors, and then dial 99. Since 99 is busy, the rotary stepping circuit of the connector should advance it to the last step, No. 90. This tests the connector for passing busy numbers and stopping on the first idle one. Conduct other tests in the same manner as for regular connectors.

g. USING TEST TELEPHONE HANDSET (figs. 11 and 12). When testing connectors with the test telephone handset, always dial the test number, or the number of a telephone located in the switchroom, to avoid ringing telephone lines unnecessarily.

h. TESTS WITH STEPPING-SWITCH TEST SET (fig. 14). The stepping-switch test set (Auto Elec H–55165–B) tests the vertical and rotary stepping and the release of the connector switch mechanism. These tests are made by the connector routine test set (fig. 13) in the course of the ringing, talk, and busy tests, but under some conditions it may be desirable to test only the switch mechanism. The stepping-switch test set tests the stepping mechanism with a high-resistance loop, or with a low-resistance loop having shunt leakage. Connect the stepping-switch test set to battery, and insert the test plug into the test jack of the connector. Operate the LOOP switch on the switchbox of the stepping-switch test set for the high resistance loop test. Operate the RLS switch to release the connector. Operate the SHUNT switch for the leakage test. The stepping-switch test set sends test pulses in series of 9, stepping the connectors vertically and horizontally to the test No. 99 or No. 299. Connectors which respond correctly are considered satisfactory. Refer to TM 11–2114 for complete information on the stepping-switch test set.

33. Reverting-call Operating Tests

a. Reverting-call switches may be tested by lifting the handset from the cradle of any telephone under test dialing the special reverting-call number, usually No. 19, and replacing the receiver on the hookswitch. The ringer of the telephone set should sound intermittently until the handset is again lifted. This should stop the ringing, and again replacing the handset permits the switch to release. If two telephones are installed in the switchroom, wired for two-party

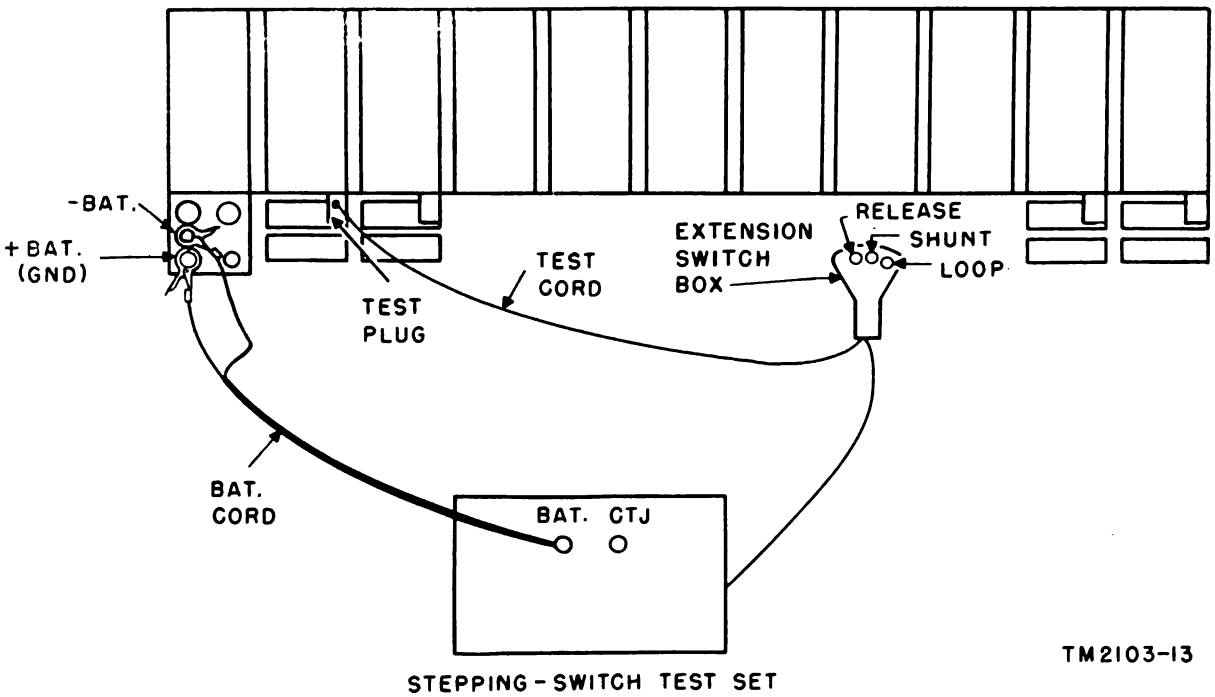


Figure 14. Cord connections for stepping-switch test set.

service, a test can be made for ringing both parties. Lift the handset of one telephone, dial the reverting-call number, and replace the handset. Note that both ringers sound. Lift one handset to stop the ringing. With both handsets lifted from the cradle, make a talking test to verify the operation of the battery supply circuit of the reverting-call switch. Replace both receivers and note that the reverting-call switch, special second selector and linefinder release.

b. Reverting-call switches may also be tested with the connector routine test set (fig. 13). Connect the CALL cord test plug into the test jack of the reverting-call switch. Note that the RT lamp on the test set glows. Operate the RC RING-RC RCO switch to the RC RING position. The test set ringer should sound. Operate the RC RING-RC RCO switch to the RC RCO position to stop the ringing. Release the reverting-call switch by operating the RLS switch. Refer to TM 11–2113 for complete information on the connector-routining test set.

34. Selector Cut-in and Release Tests

a. Routine Selector Tests with the Stepping-Switch Test Set (Auto Elec D–55165–B). Connect the test plug of the stepping-switch test (fig. 14) into the selector test jack. Operate the LOOP push-switch and note that the selector operates to the ninth vertical level and that rotary stepping cuts in at this level. If all trunks are busy, or if the ninth level is vacant, the selector will step to the eleventh rotary step and connect busy tone. If any trunks are connected to the ninth level, the selector will stop at the first idle trunk. Momentarily operate the vertical off-normal switch lever, at the top of the switch frame, and note that the selector advances to the next trunk. Failure to advance indicates an open circuit in the trunk. Test each trunk in this manner. Test one of the trunks that the selectors indicate is busy by observing which selector in the group is using that trunk, and by monitoring with the test telephone handset (Auto Elec L–965–AO). If no trunks are busy, make them busy by operating the busying switches (busy keys) on the shelf of the units into which these selectors are trunked, and observe that the selectors do not stop on the busy trunks.

b. Routine Selector Tests with the Test Telephone Handset (figs. 11 and 12). A selector may be tested on all of its levels by using the test telephone handset (Auto Elec L–965–AO) and dialing the selector level desired. Test the rotary stepping action on each level in the same manner as above. If the selector is a regular first or second selector, dial the test number in the connector groups for each test.

35. Interoffice Trunk Tests

Although interoffice trunks are usually in constant use by the switchboard operators and troubles on them are ordinarily reported at once, routine tests of the trunks and the associated pulse repeaters and incoming first selectors must be made to insure satisfactory operation of the dial circuits. Use the test telephone handset or the stepping-switch test set to make these tests. Make the tests in coordination with a man in the distant dial central office, after first testing the selectors.

a. Tests with the Stepping-Switch Test Set (fig. 14). Connect the test plug into the test terminals of the repeater. Operate the LOOP push-switch, while the man at the distant office observes the functioning of the incoming selectors. Operate the RLS push-switch, and again test by operating the SHUNT push-switch. This gives a performance test of the repeaters and selectors with standard limits of trunk line resistance and leakage.

b. Tests with the Test Telephone Handset (figs. 11 and 12). When the trunk tests are made with the test telephone handset, connect the test plug into the test terminals on the repeater, with the test plug push-switch button downward. Hold push-switch R on the handset operated, and dial the desired selector level of the distant office, while the man at the distant office watches the functioning of the incoming selectors. Release push-switch R and operate push-switch C. This permits the trunk equipment to release.

c. Tests at Distant Dial Central Office. When all the trunk tests are completed from the local dial central office, the man at the distant dial central office should perform the same tests, while the functioning of the incoming selectors is observed in the local office.

36. Insulation Resistance Tests

a. Periodical measurement of the insulation resistance of the switch bank multiple cables and trunk cables is necessary, to determine whether moisture absorption or deterioration has occurred. Tests of the bank multiple cables will show whether the equipment in the dial central office has been exposed to and affected by high humidity conditions warranting corrective measures. The minimum standard of in-

sulation resistance has been established as 350 meg (megohms) per pair of contacts. In completing a call from a line entering at 1 pair of CDF terminals, through the switch banks, wipers, trunks, terminal boards, cables, and back to the outgoing line terminals at the CDF, insulation resistance of more than 100 contacts may be in parallel. (Remember that switch contact banks of each shelf are multiplied.) The minimum desirable over-all insulation resistance is 1 megohm (1,000,000 ohms). This is 350 megohms divided by the number of contact pairs involved in placing the call.

b. When measuring insulation resistance in the dial central office, the lines or circuits must be cleared of any battery connection or bridged coils. The test is usually made through the wire chief's test desk, using either the Wheatstone bridge or the volt-ohm-milliammeter. Older type test desks have a voltmeter with series battery in place of the volt-ohm-milliammeter, but all are equipped with a Wheatstone bridge. The bridge provides the higher resistance range and greater accuracy for this test. See TM 11–2110 for procedures in making the resistance measurements.

c. To make insulation tests at linefinder or connector banks, open the substation line circuits at the CDF (MDF) by removing or insulating the heat coils. The test is made from the test desk over the test switch train, through dialing the number of each individual line to be tested. Test with the volt-ohm-milliammeter by connecting the primary test cord to the test distributor trunk jack and operating the HI switch to the OHM-HI position. An alternate method is to test with the Wheatstone bridge by connecting the WB cord to the test trunk jack and operating the WB switch on the test desk to the WB position. This removes the shunt leakage of the outside line. The test distributor operates the line relay, disconnecting the coil of the line relay normally bridged across the line. After making the test, return the circuits to operating condition, and repeat the test procedure for each line associated with the banks.

d. When testing trunks from first selectors to second selectors, block the armature of relay D in the second selector in the operated position in order to disconnect the battery voltage and relay coils from the trunk. Operate the busying switch on each selector before testing. When testing a trunk from selectors to connectors, remove the connector from the shelf, since it is difficult to clear the trunk otherwise.

e. Test the outside plant line insulation from the test desk, using the CDF test shoe and either the Wheatstone bridge or the volt-ohm-milliammeter. In wet weather, the insulation resistance of telephone lines should be a minimum of 15,000 ohms while that of interoffice trunks should be not less than 30,000 ohms. In dry weather, an insulation break-down test should be made on each line. The insulation resistance of any line in dry weather after the break-down test should be not less than 25,000 ohms. Any lines not meeting this standard should be inspected for trouble or deterioration. The above resistance values are the resistance between conductors, or between the conductors in parallel and ground.

f. Low insulation resistance on all or most of the central office wiring indicates excessive dampness. Use heaters, either electric strip heaters or heaters equipped with fans, to dry out the insulation (par. 9). If low insulation resistance is found on only a few lines or trunks, inspect these lines for insulation leakage troubles. If the leakage is in bank contacts and cannot be easily corrected, it may be necessary to transfer the line to another number or terminal having normal insulation resistance.

CHAPTER 3

TROUBLE SHOOTING

Section I. CENTRAL OFFICE SPECIFICATIONS, DRAWINGS, AND RECORDS

37. Equipment Specifications and Drawings

a. GENERAL. Before attempting trouble-shooting operations, thoroughly study the manufacturer's equipment specifications. These contain the type numbers and part numbers of the equipment, the drawing numbers of the wiring diagrams, circuit schematics, and maintenance drawings, as well as a description of the method of operation of the central office and individual equipment. These specifications and drawings should be located in the wire chief's files. If the wire chief's papers are incomplete for any reason, request copies or substitutes of required items, through channels, from Army Communication Service Division, Office of Chief Signal Officer. The following sub-paragraphs list some of the specifications and drawings supplied by the manufacturer for the wire chief's files. Typical examples of sequence of operation, trunking, and numbering are given in section II as a guide in trouble shooting.

Caution: There are numerous inconsistencies in abbreviations used by the manufacturer. One abbreviation may stand for several different terms, or several different abbreviations may stand for one term, even on the same drawing. The abbreviation must be considered in context.

b. EQUIPMENT SPECIFICATIONS. The manufacturer's equipment specifications are numbered serially, with a 4-digit job number for the particular central office, plus a standard suffix number indicating the type of equipment covered by the specification. The specifications list the part numbers of the equipment components, the drawing number and suffix of the circuit diagrams, and general notes on installing, interconnecting, and operation.

Table VI. Manufacturer's Equipment Specifications

Equip. spec suffix No.	Contents
600	Attendant's switchboard, equipment and installation.
702	Cabling, cable runs, forming, and installation.
703	Cable runways.
722	Frames for switching equipment.
723	Linefinder, line equipment, selector, connector, repeater and miscellaneous shelves, equipment and installation.
725	Testing equipment, installing material, maintenance tools and spare parts.
726	Crash and conference relay rack and equipment.
729	Relay rack and equipment for attendant's switchboard.
750	Test desk, equipment, and installation.
767	Power, ringing and supervisory equipment, and installation.
769	Distributing frames, equipment and installation.
792	Installing information, summary of drawings (central office files) and central office method of operation.
ACMO	Attendant's switchboard, method of operation.
TDMO	Test desk, method of operation.

c. CENTRAL OFFICE DRAWINGS. The manufacturer makes a number of drawings of the plans, cabling, system schematics, supervisory circuits, equipment locations, and interconnections. These drawings are individual to each office and are serially numbered. The number assigned to the individual drawings consists of the central office serial number plus suffix letters denoting the type of drawing. The numbers are in the series H–57000 or H–76000, except that power board and power circuit drawings are in the H–93000 series. For example, a number H–76424–LFL indicates a drawing of linefinder shelf location for a particular office, and H–76424–SD indicates the schematic cabling diagram of the same office. H–93295–RTC indicates the ringing and tone circuit for a central office where specified.

Table VII. Central Office Drawings

Drawing No. suffix	Equipment covered
CDF	Combined main, line, and trunk distributing frames.
CL	Connector shelf location.
CP	Cable plan.
CR	Cable runway.
F	Floor plan.
LFL	Linefinder shelf location.
LFN	Linefinder to first selector cross-connecting scheme.
RR	Relay rack, conference group.
SD	Schematic cabling diagram.
T-101	Distributing terminal assembly (selector, cross-connections).
T-103	Distributing terminal assembly (selector, cross-connections).
TR-1	Repeater and miscellaneous shelf location.

Table VIII. Power Drawings

Drawing No. suffix	Equipment covered
C	Power circuit.
C1	Supervisory wiring diagram.
C2	Supervisory schematic diagram.
RTC	Ringing and tone circuit.
S	Power board stocklist and assembly.

d. COMPONENT ASSEMBLY DRAWINGS. Each component of step-by-step dial central office equipment has an assembly drawing, usually with the prefix D or H. They are often merely stocklists, having tables of the part numbers and drawing numbers of the items making up the component and all its variations. The drawing number of the item is also the part number, except for some small parts such as relay coils, wire-wound coils, and switchboard lamps. In these cases, many similar parts are grouped on one drawing, and the drawing number then differs from the part number. Prefixes sometimes used for drawings of subcomponents are D, H, L, M, MC, MP, R for relays, and RT for twin-contact relays. The drawing numbers include suffix letters denoting manufacturing variations. A separate stocklist for each suffix letter is sometimes shown. The wiring diagram for each variation is sometimes shown in a separate table near the title block.

e. MAINTENANCE DRAWINGS. Maintenance drawings are pictorial sketches of components of the equipment with part numbers indicated by call-outs on the body of the drawing. This type of drawing carries the part number of the component, plus the prefix MD. For example, assembly drawing D-857015 has an associated maintenance drawing MD-857015. The MD drawings are useful in identifying manufacturer's part numbers of replaceable parts when repairing equipment.

f. CABLE FORM AND TERMINAL BOARD COLOR CODE. Drawings of cable forms and terminal board (block) color codes are in tabular form. One drawing number is assigned to an entire series of tables. Each table is a separate sheet and is identified as a figure. Thus H-26587-Fig. 35 shows color codes for one type of terminal board (block), and H-26587-Fig. 269 for another type of terminal board (block). The applicable figures are specified by the design engineers, and the proper sheets are included in each central office file for the wire chief and installation personnel. The same system also applies to cable form drawings, except that suffixes are letters instead of figures.

g. WIRING DIAGRAMS. The wiring diagrams of major items such as switch shelf assemblies cover all models and variations of those items. Wiring diagram numbers have the prefix H. Each drawing may consist of a number of figures on one sheet. The proper figures for the particular model of equipment actually used are specified on the main assembly drawing of the item, or in the job specification. Carefully study the drawings, notes, and specifications, and mark the wiring diagram to show clearly the correct application of figures and details. Not all components have actual wiring diagrams, the schematic circuit diagram being the only reference. In some cases wiring diagrams are included on the assembly drawing. In other cases, a combined circuit schematic and wiring diagram is made.

h. SCHEMATIC CIRCUIT DIAGRAMS. For the switching equipment components, such as linefinders and pulse repeaters, a schematic circuit diagram is issued, which indicates all wiring variations and some manufacturing changes. The variations are included on the body of the drawing, indicated by dashed lines, alternate connections, and shill or labels such as *X-wiring, Y-wiring,* and *R-wiring.* A column of notes indicates *Fig. 1, use X-wiring, Fig. 2, use Y-*

wiring, or states what manufacturing changes cause variations. The equipment job specification listing equipment part numbers also lists the schematic circuit number, and specifies the applicable figure number. The assembly drawings of the component sometimes specify which schematic circuit figure numbers apply to the stocklist suffixes indicating model variations. These references are the only guides for determining the actual schematic circuit of the equipment supplied in the central office. Carefully study the specifications, assembly drawings, and schematic diagrams. Determine which figures and wiring variations are specified, and mark the schematic diagrams to provide a ready reference for the actual circuits of the equipment used in the central office. The prefix of schematic circuit numbers is H.

i. CIRCUIT EXPLANATION SHEETS. Each schematic circuit diagram has an associated explanation sheet providing a complete description of the circuit features, sequence of operation, and functions of components. Since the schematic circuit diagram covers many variations, the circuit explanation sheet explains all the possible features, functions, and sequence of operation. The circuit explanation sheet should therefore be marked to indicate items not pertinent to actual conditions in the central office. Circuit explanation sheets have the same number as the schematic circuit, except that the prefix is E.

j. RELAY ADJUSTMENT SHEETS. The functions and operating requirements of relays used in each circuit differ greatly. Standard adjustments and operate and nonoperate current limits of relays are determined separately for each circuit. A relay adjustment sheet is then prepared for each circuit showing the standard requirements and adjustments for all relays used in that circuit. An explanation of the relay adjustment sheet is given in paragraph 58. The relay adjustment sheet is usually given the same number as the circuit, plus the prefix AH. Exceptions are sometimes made in which the relay adjustment sheet carries the part number of the unit, such as A–205212 for selector switch D–205212–A.

k. STANDARD ADJUSTMENT SHEETS. Requirements and mechanical adjustments of switches, switch mechanisms, and other apparatus are supplied in a series of standard adjustment sheets. These have prefix A, and are numbered from 100 upward: for example, A–100, A–135. Special adjustment sheets for specific items of equipment are given the part number of the equipment, plus the prefix A. Relay part No. D–55245 thus has a special adjustment sheet A–55245.

38. Central Office Records

a. GENERAL. Accurate records are necessary to permit adequate step-by-step dial central office maintenance. The wire chief is responsible for keeping accurate records and reporting the condition and service performance of the central office. The necessary forms are listed in appendix I. These forms are AGO forms obtained through normal AG supply channels.

b. CABLE RECORD. When a telephone is to be installed, the wire chief is advised of the location, name of user, and type of service required. The wire chief then assigns an idle telephone number to the line and checks the Signal Corps United States Cable Record (WD AGO Form 11–146) to obtain a spare pair in the terminal nearest the location named. This information is given to the installer and posted in the cable record. The installer calls in from the terminal before connecting the telephone to be sure that the pair is good. After the telephone has been installed, the installer tests by dialing the wire chief's number. If the line is a party line, it should be assigned to a party line pair which has a party vacancy. Otherwise, a new pair must be assigned. After the telephone has been installed and tested the telephone number and cable pair location in the terminal is recorded in the cable record by the wire chief. Refer to TM 11–2102 for procedure in filling out cable record forms. The cable record is used in maintenance and trouble procedures to identify the location and to record the condition of cable pairs.

c. LINE RECORD CARD. Keep on file, in numerical order, a line record card (WD AGO No. 11–145) for *each* telephone number used in the area served by the central office. On cards listing numbers used by the second party of two-party lines, enter only the number of the second party (under LINE NO.) and the number of the first party (under TEL. NO. 1ST PARTY), to serve as a cross reference. Enter all other information pertaining to the second party in the space provided for it on the card filed under the first party's number, including trouble reported by or found at the second party. On cards for individual lines, enter the required information in the space provided for the first party, strike out the heading TEL. NO. 2D PARTY, and leave the space provided for the second party blank. Use ink for entry in LINE NO. and all entries on the trouble record (*d* below). Under LINE NO. write the telephone number of the substation to which the card refers,

for filing purposes. Make the penciled entries as follows:

1. TEL. NO. 1ST PARTY. Enter the telephone number of an individual line, or of the first party of a two-party line.

2. RING NO. Enter number of rings assigned to substation if on a party line with code ringing; otherwise leave blank.

3. CLASS OF SERVICE. Enter a letter showing the class of service to which the user is entitled. Class A is service paid by the Government; Class B is service paid by individuals or companies; Class C is service restricted to post area; Class D is service restricted to guards and fire companies.

4. DATE INSTALLED. Enter day, month, and year of installation. Do not change this date as long as the original installation remains, regardless of who occupies the premises.

5. ACCESS TO TRUNKS. Enter *yes* if the substation is entitled to service other than strictly local service. Enter *no* if only local service is furnished.

6. NAME OR OFFICIAL POSITION. Enter the user's name for a residence. Enter the official title for an office: that is, Post Signal Office or QMC depot.

7. STREET ADDRESS. Enter street address only if needed. Ordinarily, enter here the rank and organization of the user.

8. BUILDING NO. Enter building number or quarters number.

9. AUTHORITY FOR INSTALLATION. Enter the work order number and date, or other authority for the installation.

10. LOOP RES. OF LINE. Measure accurately the loop resistance of the line, and enter it here. Check this reading when making continuity tests thereafter.

11. TEL NO. 2D PARTY. Enter information pertaining to the second party, if any, on items 11 through 20 similarly as for items 1 through 10 above.

21. SUBSTATION DATA. Enter the following information for each party. Under TELEPHONE show the abbreviated name of the manufacturer, and W or D to indicate wall or desk telephone. Under BOX CODE show the manufacturer's code for a bell box if installed separately, or his code number for a wall telephone. Under STAND. CODE show the code for a desk stand if installed, or leave blank if a wall telephone is used. Under EXTEN. CODE supply the same information for an extension subset, if one is installed. Under ARRESTER show the manufacturer and his code for the type of arrester installed. Note that CABLE and PAIR appear twice. Use the first two columns for recording the cable and pair number of a via, a through type trunk or line, or for a multiple connection. Under the second CABLE enter the number of the cable in which the line circuit pair is located. Under the second PAIR enter the number of the cable pair furnishing service to the substation. Under TERM. enter the number of the terminal box from which the drop is run. Under PINS enter the pin number to which the drop is connected in the terminal box.

22. LINE RELAY NO. Enter the number of the line relay associated with the line.

23. Enter the linefinder group number and terminal number.

24. Enter the connector terminals to which the linefinder terminal is crossconnected.

d. TROUBLE RECORD ON LINE RECORD CARD.

(1) Under the heading REPORTED are the subheadings DATE, HOUR, BY, and TROUBLE. Fill in the following information:

(a) DATE. Enter the date trouble is reported.

(b) HOUR. Enter the time trouble is reported.

(c) BY. Enter *Sub* (for subscriber) if a user reports the trouble. If a trouble man, chief operator, or operator makes the report, enter his number or initials.

(d) TROUBLE. Enter abbreviation (*e* below) to describe trouble reported.

(2) Under the heading TEST SHOWED enter abbreviation such as *gnd* (ground) or *short*, to show the result of the line test.

(3) Under the heading TROUBLE FOUND show the nature of the trouble actually found.

(4) Under the heading CLEARED are the subheadings DATE, HOUR, and BY. Fill in the following information:

(a) DATE. Enter the date trouble is cleared.

(b) HOUR. Enter the hour trouble is cleared.

(c) BY. Enter the number or initials of the person who cleared the trouble.

e. ABBREVIATIONS USED ON LINE RECORD CARD. Use the following abbreviations on the trouble record:

(1) Cannot call—C C
(2) Cannot hear—C H
(3) Cannot be heard—C B H
(4) Bells do not ring—B D R
(5) Bells weak—B W
(6) Cords out of order—Cds Od
(7) Noisy—Nsy
(8) No disconnect signal—N D S
(9) Permanent signal—P S
(10) Permanent ground—P G
(11) Swinging ground—S G
(12) No trouble found—O K
(13) Swinging cross—S X

f. Weekly Storage Battery Report. It is important that accurate battery records be kept in order to provide a complete history of battery service, use DA AGO Form 11–24 (Weekly Storage Battery Report) for central office main batteries. Read all cells on the same day of each week, and record the readings. Read and record daily the specific gravity of the pilot cell of all the batteries. Use the remarks column to record when water is added, and any unusual condition found in connection with battery maintenance.

g. Connector Terminal Record. Use DA AGO Form 11–208 (Connector Terminal Record) as a basic record of assigned telephone numbers and an index of the crossconnection to linefinder groups. Number assignments in the connector groups are made on the basis of class of service and traffic distribution. Refer to TM 11–2102 and TM 11–2109 for number assignment procedure. The standard crossconnecting straps between connector terminals and line finder terminals will not require changes in most cases, but distribution of party-line service, traffic loads, and restricted-service lines, or changes in number assignments and locations, will require replacing the straps with jumper wires. Enter the linefinder groups and linefinder terminal numbers assigned for all connector terminal numbers. Enter the class of service (*c* above) and indicate whether first party on the line or second party. The connector terminal record applies to 100-line regular or trunk-hunting connectors, and to the first 100-group of 200-line connectors. Use a second sheet for the other 100-group of 200-line connectors, adding the required digit to the terminal number.

h. Linefinder Terminal Record. After line assignments and cross-connections between linefinder and connector banks have been completed, use DA AGO Forms 11–209 and 11–209–1 (Linefinder Terminal Records) to enter the telephone number of each party and class of service that has been assigned to each linefinder terminal. This gives an essential reference for maintenance and trouble-shooting operations and for traffic distribution and number changes. Each time a number assignment or class of service is changed, enter changes in the linefinder and connector terminal records.

i. Telephone Trouble Report. DA AGO Form No. 11–23 (Telephone Trouble Report) is provided for entering service complaints of trouble or service interruptions reported by substation users or found by maintenance personnel in testing outside lines. This form is used as a basis for dispatching trouble crews. Enter complaints as follows:

(1) At top of form enter telephone number, location, trouble reported by, and date and hour reported.
(2) Make entries in the center of form to indicate types of trouble which must be checked.
(3) Enter at bottom of form the trouble found, date and hour found, date and hour cleared, and by whom the trouble is cleared.
(4) After the trouble crews have cleared the fault, enter the information on the Line Record Card (WD AGO Form 11–145), and then file the Telephone Trouble Report (DA AGO Form 11–23) in the numerical order of the telephone numbers.

j. Daily Trouble Record. A daily record of faults reported and being cleared will assist in supervision of trouble-shooting and fault-clearing operations. Use DA AGO Form 11–206 (Daily Trouble Record). The form is self-explanatory. Use one form at the wire chief's test desk to record each complaint as received. When trouble is cleared, enter nature of trouble on the record. This will provide a ready reference of troubles reported, assigned for clearing, and remaining to be cleared. Use another form in the switchroom to record faulty equipment found in routine tests or in trouble shooting. This will provide a record of work to be done in clearing faults or scheduling repairs to the central office equipment.

k. Routine Progress Record. Use DA AGO Form 11–207 (Routine Progress Record) during routine tests. Enter the switches tested and those remaining to be tested, and the number of faults detected. The record will show whether the interval between routine tests should be changed. When very few faults are found, the interval can be increased. If undue numbers of faults are found, it is apparent that the interval between tests should be decreased

and routine inspections and adjustments of the switching equipment should be rescheduled. In central offices having a large number of switches, the routine progress record permits dividing the time on tests, and shows the number of switches completed and those remaining to test.

Section II. THEORY OF OPERATION

39. Major Equipment and Method of Operation

a. Refer to TM 11–2100 for the theory of operation of equipment used in typical step-by-step dial central offices. Refer to the appropriate technical manual, listed in appendix I, for detailed information on specific step-by-step dial central office equipment components. The following is a brief description of typical equipment and method of operation.

b. Step-by-step dial central office equipment is usually designed for 46/52-volt common-battery operation, using two-wire outside lines of 1,000 ohms maximum loop resistance. The switching equipment of a typical 2,000-line central office comprises line relays, linefinders, first and second selectors, special second selectors, 200-line regular connectors, 100-line trunk-hunting (PXB) connectors, miscellaneous switches. This equipment also comprises supervisory, power, and test equipment as indicated in the equipment specifications.

c. When the calling party removes the handset from the cradle, the circuit of the line relay associated with the calling line is completed. The line relay operates, causing a linefinder in the particular line group to search automatically for the line. When the linefinder has seized the calling line, the connection is completed through to the associated first selector. The first selector returns dial tone to the calling party. This occurs so rapidly that the dial tone is received almost as quickly as the handset can be raised to ear level. However, if traffic is so heavy that all linefinders are busy, no dial tone is heard and the call must be placed at a later time.

d. As each digit is dialed, a series of pulses (current interruptions) is transmitted over the line to the central office switching equipment. The number of pulses in each series corresponds to the digit dialed. Pulses from the first digit step the wipers of the first selector vertically up to the corresponding bank level. The rotary motion of the first selector is automatic. Its wipers search over the contacts on the dialed level for a free trunk to the next switch. If the selector reaches a free trunk, the calling line is extended through to the next switch. This is either another selector or a connector, depending on the trunking arrangement of the central office and the type of call being made. When the next switch is a second selector, the second digit dialed selects the vertical bank level, and the atomatic rotary circuit searches for a free trunk to a connector. If no free trunk is found by the first or second selector, the selector in question returns busy tone. In periods of heavy traffic, busy tone may be received before all digits are dialed, and completion of the call prevented. If equipment faults tie up switches or trunks, this difficulty will be increased.

e. Two digits are dialed to complete the vertical and rotary stepping in 100-point connectors. Three digits are required for 200-point connectors, the first of which chooses between upper and lower banks. The connector tests the called line, sends back busy tone if the desired line is in use, or rings the line if it is not in use, at the same time sending ring-back tone to the calling line. Ringing cut-off is automatic when the called party answers. The connector extends negative (talking) battery to both calling and called parties. Release of the connector takes place only when the last party hangs up. PBX (or trunk-hunting) connectors can be arranged to search over groups of lines and ring the first one found not busy. In this case, busy tone is sent back after the last line of the group has been tested and found busy.

f. Trouble-shooting procedures vary with the type of equipment and the trunking arrangement used in a central office. Study the central office schematic diagrams, circuit explanation sheets, and the equipment specifications before attempting trouble shooting.

40. Trunking Arrangements

a. A schematic cabling diagram (SD) is included in the manufacturer's drawings issued for each step-by-step dial central office. The diagram is a schematic representation of the cabling between groups of switching equipment in the central office, and provides a general picture of the trunking arrangements. Figure 100 represents a typical 1,000-line step-by-step dial central office, based on an actual

schematic cabling diagram, and using the manufacturer's nomenclature and abbreviations. Figure 101 similarly represents a typical 3,400-line step-by-step dial central office. Both of these are examples of recent installations. The switch groups are shown as blocks, with titles indicating the type of equipment. For example, REG CONN (200–L) refers to 200-point regular connector groups. The other symbols in the blocks are the drawing numbers of the manufacturer's schematic circuit diagrams for the individual switches. Cabling between the switch groups is indicated by lines between the blocks. The circled numbers inserted in these lines are the cable run numbers. A cable run may consist of any required number of cables leading between the designated groups. Details of the cable runs are given in the cabling specifications, and the cable plan and cable layout drawings issued by the manufacturer for each step-by-step dial central office.

b. In figure 100 notice that no second selectors are used (except for the special second selectors giving access to certain services), and the first selectors are trunked directly to the 200-point regular connectors. The 100-point PBX connectors trunk from the first level of the first selector to the tenth (0) level of the special second selector. With this system, all telephone numbers have four digits. Notice also that no interoffice trunking is shown in figure 100, although central offices usually will have trunk lines, with pulse repeaters, to one or more other central offices or city exchanges, similar to the facilities shown in figure 101 for the 3,400-line step-by-step dial central office.

c. The 3,400-line step-by-step dial central office shown in figure 101 requires two regular (or *local*) second selector groups, since not enough trunks are available in the first selectors to route calls to all the connector groups. Notice that first selector levels 4, 5, and 6 (fig. 101) are trunked directly to connectors, while levels 2 and 3 trunk through second selectors. Trunking of PXB lines in the 3,400-line step-by-step dial central office is the same as described above for the 1,000-line step-by-step dial central office. The special service trunks to the special second selectors also are the same.

d. The above examples of trunking arrangements indicate that trunks leading from similar units in each type of step-by-step dial central office do not always terminate in the same circuits. Before testing any units or attempting trouble-shooting operations, study the schematic cabling diagrams, the manufacturer's equipment specifications, the schematic circuit diagrams of the equipment, and the shelf wiring diagrams so that the trunking arrangements and the circuits terminating the trunks are completely understood.

41. Numbering Plans of Typical Step-by-step Dial Central Offices

a. NUMBERING PLAN FOR 1,000-LINE OFFICE.

(1) *Individual line or first party on two-party lines.*

2100–2198	4200–4298
2200–2298	5100–5198
3100–3198	5200–5298
3200–3298	6100–6198
4100–4198	

(2) *Second party on two-party lines.*

6200–6298	7200–7298
7100–7198	

(3) *Private branch exchange lines (PBX).*

1001–1089
1091–1098

(4) *Test numbers.* The regular 200-point connectors have a test number assigned in each 100-group, No. 199 for the first 100-group and No. 299 for the second 100-group. Corresponding numbers are assigned on the linefinder banks, No. 29 and No. 199. The line equipment associated with these linefinder test numbers is not available for assignment to regular station numbers. On PBX 100-point connectors, the test numbers are No. 99 and No. 90. No. 99 is made busy, to provide a test of the automatic rotary stepping.

(5) *First selector level assignments in a typical 1,000-line system.*

Level 0	Operator	Level 5	200-point connectors.
Level 9	Interoffice trunks (when required).	Level 4	200-point-connectors.
Level 8	Interoffice trunks (when required).	Level 3	200-point connectors.
Level 7	200-line connectors	Level 2	200-point connectors.
Level 6	200-line connectors	Level 1	Special second selector.

(6) *Special second selector level assignments.*

Level 0	PBX connectors (100-point).
Level 9	Reverting-call switch (test ringback).
Level 8	Wire chief's test desk.
Level 7	Fire repeaters.
Levels 6, 5, 4, 3, 2, 1	Vacant.

b. NUMBERING PLAN FOR LARGER SYSTEMS. In step-by-step systems larger than 1,000 lines, additional selectors are required to route calls to the 2,000-group and 3,000-group of connectors. This results in mixed 4- and 5-digit numbering for the telephone lines. Some of the first selector levels are assigned to the second selector trunks. Levels of the second selectors are assigned to connector trunks or left vacant, as required. Test numbers remain as before.

c. SECOND PARTY ON TWO-PARTY SERVICE. Additional connectors are supplied in some central offices to provide service for the second party on two-party lines. These connectors do not differ from the other regular connectors. The numbers for the second party in typical step-by-step dial central offices are assigned in separate 100-groups. The terminals of these connectors are then cross-connected to any desired first-party terminals. Notice that the connectors supplied for second-party service could be used for first-party or individual line service. The cross-connection of terminals is made by cutting the strap between the first-party connector and linefinder terminals on the horizontal side of the CDF and running jumpers to the required terminals. The cross-connection for the second party on the line is made with reversed polarity, so that the connector will ring from plus line to ground instead of from minus line to ground (divided ringing), and this requires no circuit change in the connector.

d. RESTRICTED SERVICE. Restricting access to certain interoffice or city trunks groups is accomplished by operation of spring-leaf contacts (termed *normal post springs*) on the linefinder and first selector (fig. 21). The contacts are actuated by a sliding toothed striker (commonly termed *normal post cam*) coupled to the switch shaft. The restriction works only when the contacts of both linefinder and first selector are operated, as the contacts are connected in series. To operate the normal post contact springs (fig. 21) at any desired vertical level bend the corresponding normal cam post tooth (fig. 21) 90°. On the first selectors, bend the normal post cam teeth at the levels serving the trunks to which access is to be restricted; on the linefinders, bend the normal post cam teeth at the levels serving the lines that are to have restricted service. This restricts service to all the lines on the linefinder level, and therefore unrestricted and restricted lines must be assigned to different levels. The normal post cam teeth must be adjusted on all switches on a shelf. On linefinder shelves the line bank appearances are reversed between groups A and B. For instance, a line appearing on level 2 of group A also appears on level 9 of group B, and to restrict the line requires adjusting the tooth for level 2 on all switches in group A and for level 9 on all switches in group B.

Section III. TROUBLE-SHOOTING PROCEDURES

42. Classification of Faults

Trouble shooting is a process of localizing troubles or service faults that have occurred in the step-by-step dial central office equipment. Supervisory signals in the step-by-step dial central office give warning of many of the troubles occurring in the system. Other troubles are brought to the attention of step-by-step dial central office maintenance personnel by reports from substation users or switchboard operators. When clearing cases of trouble, first determine whether the trouble is in the dial central office equipment or in the outside plant. This manual discusses outside plant troubles only to the extent that they affect the central office switching equipment.

a. OUTSIDE PLANT. Faults or troubles in the outside plant usually must be cleared on the spot by a repairman. In this case, remove the heat coils from the line at the CDF (MDF) to clear any affected switchroom equipment. Refer to TM 11–468, Substation Maintenance; TM 11–757, Principles of Line Fault Location; and TM 11–2110 for the procedure in checking and clearing outside plant

troubles. The most common types of outside plant troubles are as follows:

(1) Opens in cable pairs, drop wires, telephone line protectors or wiring, and telephone sets. These result in trouble reports, but usually do not affect step-by-step dial central office equipment.

(2) Short circuits in cable pairs, drop wires, telephone line protectors or wiring, and telephone sets. These cause switching equipment to hold operated and result in *permanent* supervisory signals on the affected equipment.

(3) Grounds in cables, drop wires, telephone line protectors or wiring, and telephone sets. Ground on the negative (−) side (ring) causes a permanent signal in the central office, and sometimes may cause the linefinders to *cascade* or continuously search for calling lines (only when the individual line relay is more sensitive than the line relay of the first selector). On some installations the linefinder circuit pre-energizes the line to eliminate this possibility. Ground on the plus (+) side (tip) prevents the bell from ringing for the second party on two-party divided ringing service.

(4) Crosses (short circuits to other lines) in defective cables or drop wires. If the cross is from tip (or plus (+) side) to ring (or negative (−) side), either a *permanent* signal or linefinder cascading results. Tip-to-tip or ring-to-ring crosses result in trouble reports of cannot dial, ringing wrong line, bells not ringing, or crosstalk, but usually do not affect switching equipment.

(5) Improper use of the telephone set (for example, leaving the handset off the cradle, or dialing incorrectly). This holds the switching equipment operated and causes the *permanent* supervisory signal to operate.

b. Step-by-Step Dial Central Office Equipment. Faults occurring in step-by-step dial central office equipment, if not found and corrected, may cause service interruptions and result in trouble reports. The following common faults may cause trouble reports or operate the supervisory and alarm signals:

(1) Grounds due to operated heat coils on the CDF (MDF) protectors, or defective wiring.

(2) Linefinder, selector, or connector permanents or off-normals.

(3) Linefinder, selector, or connector failing to release.

(4) Linefinder, selector, or connector mechanism or relays out of adjustment or failing to operate.

(5) Open circuits in relay coils, contacts, resistors, heat coils, switches, or wiring.

(6) Short circuits in wiring or equipment.

(7) Crosses in jumper wires, terminal board connections, equipment wiring, or switch bank wiring.

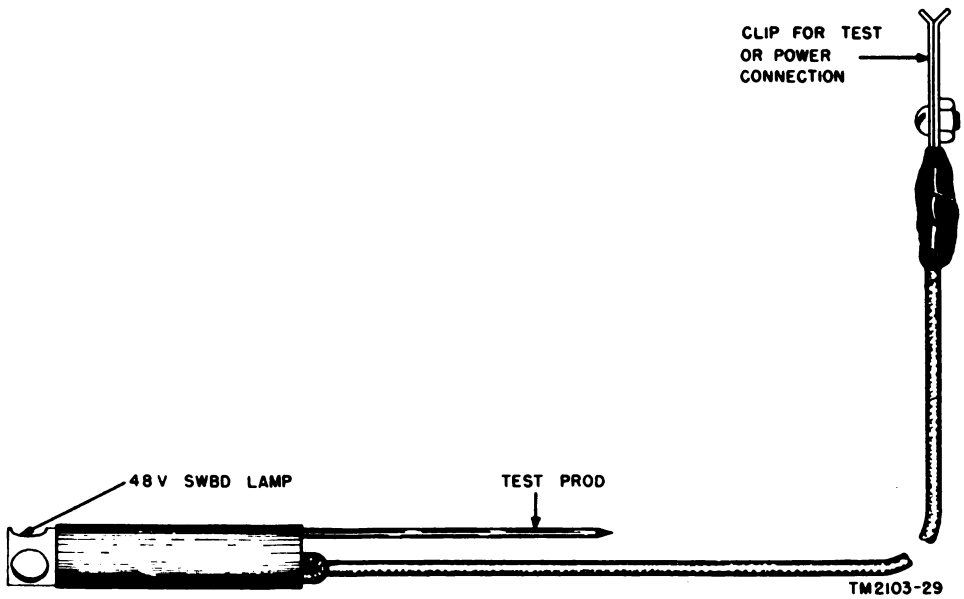


Figure 15. Test lamp.

43. Trouble Shooting

a. PROCEDURE.

(1) Faults in the switchroom equipment are partially localized by the equipment supervisory signals. The test telephone handset (Auto Elec L–965–AO) (fig. 11) can be used for monitoring circuits and further localizing some faults. A test receiver such as Test Set TS–190/U or a test lamp (Auto Elec H–16339–1) (fig. 15) may be used for continuity testing.

(2) Test outside lines from the test desk through the test switch train or through the test trunk to CDF (MDF). Test inside equipment from the test desk through the test distributor trunks or through the test trunk to CDF. Refer to TM 11–2110 for detailed information on testing procedures from the test desk.

(3) Test connectors with the connector routine test set (Auto Elec H–45987–1). Follow the procedure outlined for routine tests in paragraph 32. Test linefinders and selectors with the test telephone handset. When trouble is suspected in a switch shelf, test all switches on the shelf. Remove faulty units for repair and adjustment. Return equipment to service as soon as possible.

(4) Tests on line relays or relays in the switching equipment may be made with the current-flow test set (pars. 60 and 61). Point-to-point testing in a relay circuit may be made with a test receiver (fig. 16) or test lamp (fig. 17). The test lamp in the circuit illustrated (fig. 17) will light dimly because it in series with a total relay winding resistance of 3,000 ohms. This test lamp provides a convenient means of checking the continuity of circuit wiring, relay windings, or contacts. When testing a circuit that does not connect to battery or ground, connect the central office battery in series with the receiver or lamp. When the circuit is connected to battery but not to ground, connect one terminal of the test unit to ground and check through the circuit with the other. When the circuit is connected to ground but not to battery, connect one terminal of the test unit to negative (−) main battery.

(5) In locating faults remember three important points: first, analyze the trouble; second, refer to the step-by-step dial central office schematic diagram, the method of operation, and the circuit diagram of the affected units; third, clear the fault, after it has been localized, by point-by-point elimination. Starting at a point where the circuit is functioning properly, test the circuit a step at a time toward the fault until the fault is located.

(6) Observe certain precautions. When a fault

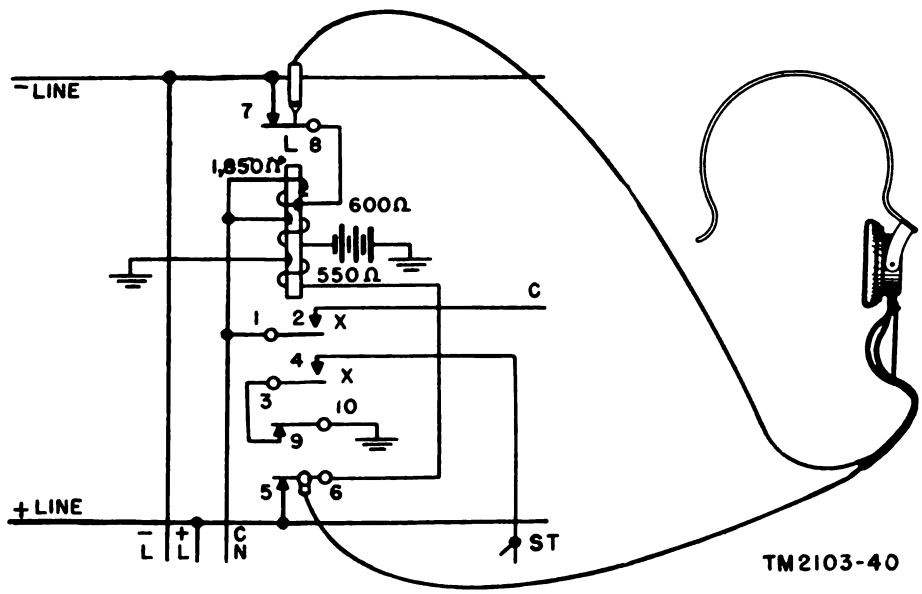


Figure 16. Checking continuity of relay winding with test receiver.

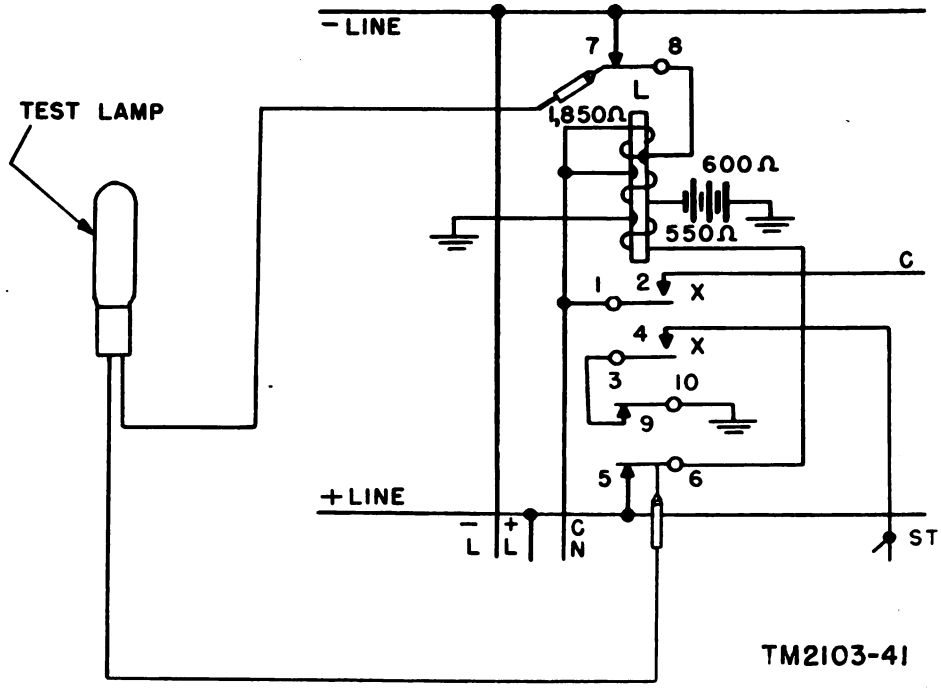


Figure 17. Checking continuity of relay winding with test lamp.

due to equipment failure is cleared, do not assume that the same fault is the cause the next time the circuit is in trouble. Locate the trouble by complete routine testing and then clear it. Do not interrupt busy circuits for testing unless absolutely necessary to do so. Always monitor the circuit to determine if it is in use. Do not test until you have asked if anyone is waiting on the line, and advise the using parties of your purpose. If a line is not in use and is to be opened for test purposes, notify the telephone user if possible. Do not keep lines and switching equipment out of service any longer than required to complete the testing.

b. Power Failures.

(1) Audible alarms call attention to step-by-step dial central office power and equipment failures. Supervisory lamp signals assist in locating the point of failure. After observing the alarm and locating the responsible circuit, check the circuit for trouble before replacing a fuse or fuses. Note that circuits fused for high current capacity normally have an associated indicator-alarm type fuse. Remember that the mechanical failure of an alarm fuse can set off the alarm circuit without an actual power failure.

(2) The power board alarm panel has an alarm bell and a buzzer, operated by dry-cell batteries. The bell rings when failure occurs in a fused circuit on the power board, in the attendant's switchboard, or in the test desk. Signal lamps associated with the various circuits indicate which circuit caused the alarm. The buzzer sounds an alarm in the event of faulty operation of switching equipment. This includes power failure, and failure of the switching equipment to start or complete its operating cycle. Signal lamps on the shelves further localize the point of failure.

(3) Figure 99 shows the location of power board visual signals, R indicating red and W indicating white lenses on supervisory and alarm lamps.

c. Linefinder Permanents and Off-Normals.

(1) Linefinder *permanents* occur when the line relay is energized and the linefinder is connected to a line but no call is being made. These are generally caused by the handset being off the cradle at the telephone set or by short circuits, grounds, or leakage on the affected line. Linefinder permanents are indicated when the supervisory signal lamp on the first selector shelf glows stead-

ily. Identify the particular linefinder causing the permanent signal by the number entered on the first selector number card. This number shows the linefinder group and number of the linefinder paired with the first selector.

(2) Identify the line causing the permanent signal by observing the vertical and rotary position of the linefinder bank wipers. For the 200-point type of linefinder, short-circuit the lower two test jack terminals. The white LB (lower bank) lamp on the linefinder fuse panel (fig. 18) glows if the connected line is in the lower bank or first 100-group and does not glow if the connected line is in the upper bank or second 100-group. Refer to DA AGO Forms 11–209 and 11–209–1 to ascertain the number of the connected line.

(3) Clear linefinder permanents by first identifying the calling line and then by using the test telephone handset to monitor and to challenge the connection. If no answer is received, test the line from the test desk and release the linefinder. Listen to determine if a handset is off the cradle. If this is the trouble, connect the howler to the line, using the test switch train and dialing the number from the test desk. If the called party does not answer, or tests indicate a ground or short circuit, open the line at the CDF and report the line in trouble.

(4) Linefinder *off-normals* are similar to permanents, except that the linefinder is not connected through to the line on whose bank-contact terminals the wipers are resting. The *off-normal* condition is indicated by the alarm buzzer on the power board. Linefinder off-normals are usually due to mechanical failure. If the linefinder fails to start, or becomes blocked before reaching the calling line and remains off-normal, the ST SIG (start signal) supervisory lamp (fig. 18) on the linefinder fuse panel glows steadily, and the delayed alarm circuit closes. The alarm buzzer on the power board alarm sounds after the delay cycle is completed. If an operated linefinder remains off-normal after the release circuit is energized, the RLS (release) supervisory lamp on the linefinder fuse panel glows and the delayed alarm sounds. In either case,

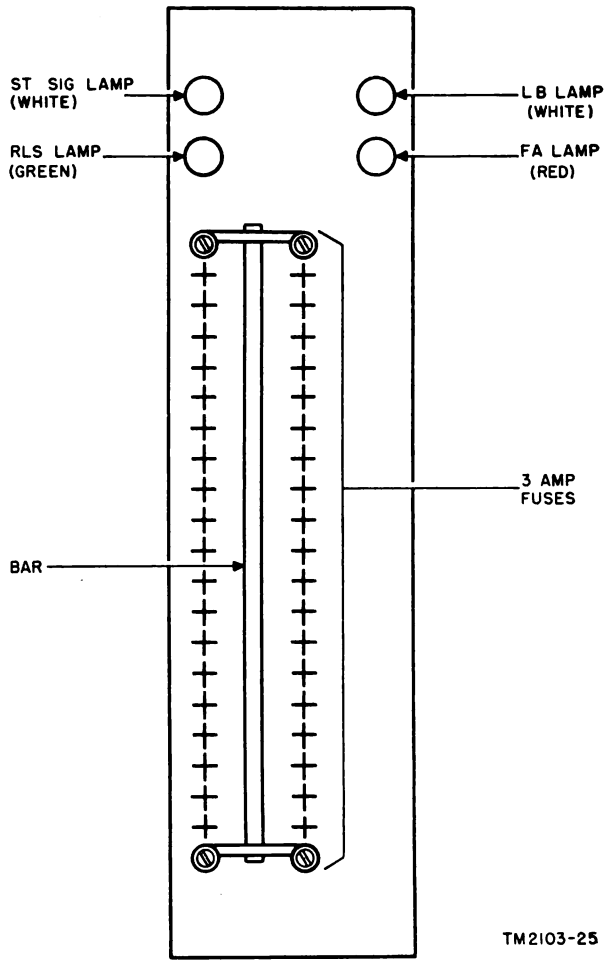


Figure 18. Typical linefinder fuse and supervisory lamp panel.

the blocked or off-normal linefinder must be cleared immediately. The alarm buzzer may be shut off at the power board, if desired. The linefinder supervisory lamps indicate which shelf is in trouble. Linefinders that are off-normal or blocked are distinguished from those that are busy by removing the covers of all operated linefinders and checking the switching-through relays (relay A or D in typical units) by lightly pressing the armature. The relay armature should be in the unoperated (normal) position on blocked or off-normal linefinders, and in the operated position on busy linefinders. On linefinders that have failed to release, the release magnet will still be energized. Monitor the circuit with the test telephone handset. Release the faulty linefinder by hand and operate its busy key to

prevent seizure of the switch on another call. Inspect the switch and correct the fault, removing it for repair if necessary.

(5) Cascading, or continuous searching of the linefinders in sequence, may be due to a ground on the negative (−) side (ring) of a line, ground on a linefinder start lead, a defective relay in the group relay equipment, or grounds in the linefinder vertical banks. First determine over which bank level the linefinder is searching. If it is the fifth level, the trouble may be due to a ground on the start lead or in the group relays. Check for loose or short-circuited wiring, particles of solder, or bent or short-circuited terminals. Check for trouble in the group relays by operating the busying switch. If the cascading stops, the group relays are at fault. If, however, the cascading now occurs in the other group of linefinders, the group relays are not at fault. Check for ground on a line by removing the covers of the affected line relays associated with the searched level, and testing the relay armatures. The armature associated with the line in trouble will operate on the first step of the wipers, but will fail to operate on the second step.

d. SELECTOR PERMANENTS. A selector *permanent* is indicated by the lighting of the white SUPY (supervisory) lamp on the selector supervisory panel (fig. 19). A selector permanent signal usually means a permanent condition in the associated linefinder. A selector permanent signal may be received when the selector line relay is operated but the switch shaft is in either the normal or unoperated position, or in the eleventh rotary position on any vertical bank level. This signal may result from failure to dial after removing the receiver, failure to replace the handset on the cradle after receiving busy tone, a short-circuited or grounded line extended through to the selector, or failure of the selector itself. Lighting of the green RLS lamp on the panel indicates failure of the switch to restore to its normal position after the dialing party has replaced the handset.

(1) When the SUPY lamp signal is noted, use the test telephone handset (figs. 11 and 12) and challenge on the line. If no answer is received, check the switch for relay failure. When selector permanent signals are due to linefinder permanents, clear the linefinder permanents to free the selector permanent signals.

(2) When the release alarm sounds and selector release failure is indicated by the green RLS lamp, first determine which selector is in trouble and restore the switch shaft manually. Inspect the switch for worn wiper tips, dirty bank contacts, binding switch shaft, and insufficient tension on the switch shaft spring. If repair of the selector is necessary, operate the busy key of the as-

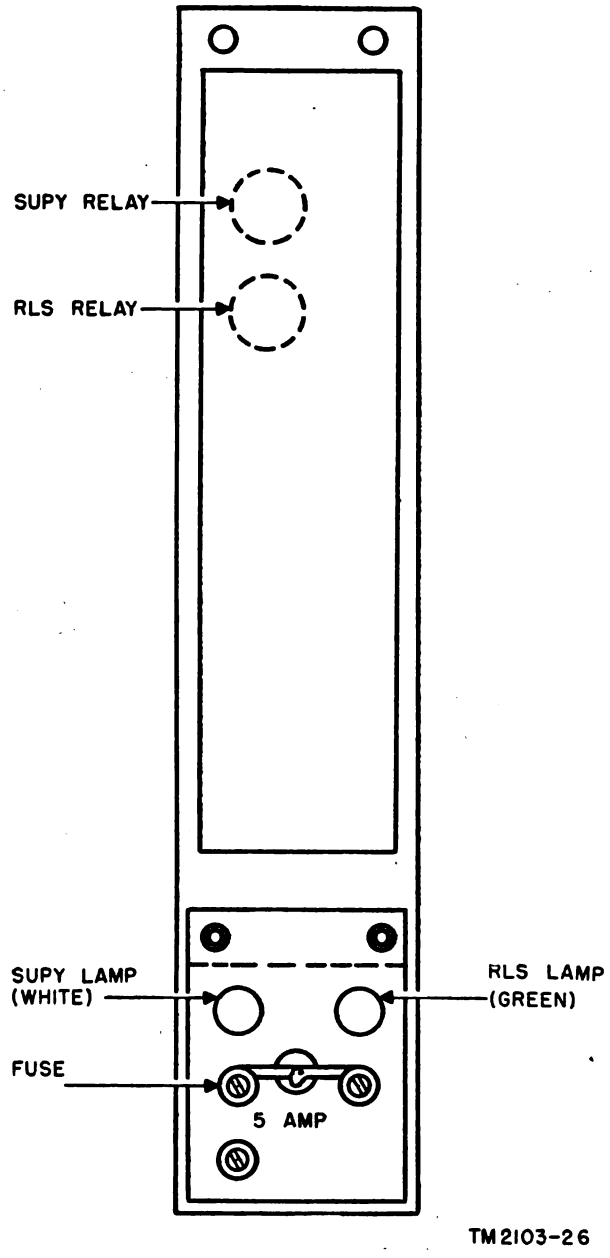


Figure 19. Typical selector shelf supervisory lamp panel.

sociated linefinder and remove and repair the selector without delay.

e. Connector Permanents and Off-Normals. A connector *permanent* results when a connector switch remains in an operated position and the white PERM lamp on the shelf supervisory panel glows steadily. A connector *off-normal* results when a connector switch fails to release and remains in an operated position, indicated by the green RLS lamp glowing steadily and the alarm buzzer on the power board operating.

(1) A *permanent* is caused by one party failing to replace the telephone handset after the conversation has ended, or by the appearance of a short circuit on the line after the connector has seized the line. An *off-normal* is caused by the failure of the switch to restore to its normal position after the release magnet circuit has been completed.

(2) Determine which connector is affected by monitoring each one which has its wipers off-normal. Remove the cover of the one in trouble, and observe the relay armatures to determine whether the calling or the called telephone is holding the connector operated. In typical connectors, relays A and B are held operated by the calling telephone, and relay D is held operated by the called party.

(3) After locating the switch causing the permanent signal, challenge on the line with the test telephone handset (figs. 11 and 12). If no answer is received, test the line from the test desk through the test switch train. Restore the switch manually by operating the release magnet armature. Connect the howler circuit to the line to attract attention at the telephone set. If this fails, open the line by removing the heat coils at the CDF. Fill out DA AGO Form 11–23 (Telephone Trouble Report).

(4) After locating the switch causing the off-normal alarm, restore the switch shaft manually to its normal position. Operate the busying switch to free the defective switch from further operation. Inspect the switch for the cause of its failure to restore. Repair and check the operation of the switch before returning it to service.

(5) Operation of the red FA lamp on the connector supervisory panel (fig. 20) and the sounding of the alarm buzzer indicates the opening of a fuse on the connector shelf. Remove the opened fuse. Check the circuit for a short-circuit overload or ground. Clear any trouble found and replace the fuse.

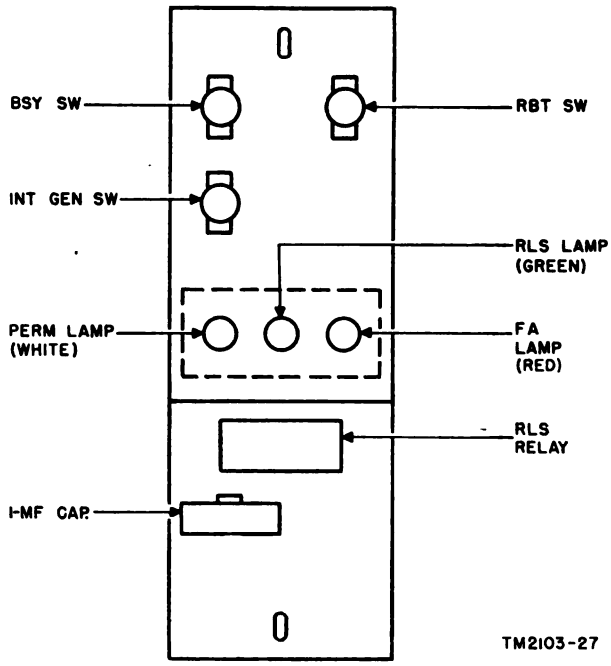


Figure 20. Typical connector shelf supervisory lamp panel.

44. Trouble Reports

Trouble reports received from users or from switchboard operators usually are due to outside plant equipment faults. However, some of the common troubles listed in trouble reports can be due to faults in the step-by-step dial central office equipment. The following are a few of the common service complaints and some of the probable causes.

a. Cannot Make Outgoing Calls. Inspect the heat coils and protector blocks at the CDF. Test the line from the test desk, using the test trunk to CDF. If the test proves the outside plant equipment not at fault, ring the telephone user and obtain details of the reported fault.

(1) If the fault seems to be in the step-by-step dial central office equipment, test the line relay. If the relay fails to operate, inspect its contacts for dirt or corrosion and improper spring tension. Clean and adjust as required. Test the relay coil for an open circuit (figs. 16 and 17).

(2) Test the start circuit to the linefinders and

the group relays. Test the resistors in the start and level-marking circuit. Test the operation of the group relays associated with the linefinder group. Refer to the manufacturer's circuit diagram and circuit explanation sheets for the function and location of the relays.

b. CALLING PARTY DOES NOT RECEIVE DIAL TONE. When this complaint is not due to line relay or linefinder faults, test each first selector in the shelf serving the group of lines having trouble reported. Connect the test telephone handset to the test jack of each first selector switch in succession, and listen for dial tone on each selector. When a selector is located that is not providing dial tone, operate the busying switch on its associated linefinder to prevent its being seized by calling lines before the condition is corrected.

(1) Inspect the make-before-break contacts on the selector *cam* (eleventh rotary step) switch assembly. Clean the contacts and adjust the contact springs as required.

(2) Inspect all other first selector relay contacts used to complete the dial tone circuit to the calling line. Refer to the manufacturer's circuit diagram for their designations and location. Clean and adjust as required.

(3) If no dial tone is heard on any selector on the shelf, check the supervisory relay on the shelf supervisory panel. The relay should be in the operated position and the white SUPY lamp should glow steadily. If the relay is not operated, test and adjust the relay. Test the dial tone induction coil (on the supervisory panel) for an open circuit.

(4) *A calling party does not receive dial tone* or *cannot make outgoing calls* complaint may be caused by unusually heavy traffic and by all linefinders and first selectors in the group serving the reported line being busy. In this case, instruct the *calling* party to replace the handset on the cradle and wait a short interval before attempting to place the call. To insure uninterrupted service, avoid having linefinders or selectors out of service for repair any longer than necessary.

c. CALLING PARTY DOES NOT RECEIVE BUSY TONE.

(1) A number of complaints from this cause indicates the need for routine tests on the connector shelf. Use the connector routine test set (fig. 13). When connectors are found that do not return busy tone, connect a test telephone handset to the test jack of the connector. Operate the relay that completes the busy tone circuit. If busy tone is not heard in the handset, inspect the relays completing the circuit for dirty contacts and improper spring tension. Clean the relay contacts and adjust the contact springs as required. Test for an open capacitor in the busy tone circuit. Remove the connector for repair if required, and return it to service as soon as possible.

(2) Test the selector switches at the test jacks for busy tone by closing the make-before-break eleventh rotary position switch contacts (sometimes called *cam springs*). If busy tone is not heard in the handset, inspect the relays completing the circuit for dirty relay contacts and lack of spring tension. Clean and adjust as required. Test the overflow busy circuit connected to the associated signal group.

d. CALLING PARTY DOES NOT RECEIVE RING-BACK TONE. Use the connector routine test set (fig. 13) to test each connector in the group serving the lines in which the fault was reported, and to locate a connector that is not providing ring-back tone.

(1) Test the ring-back tone capacitor on the connector for an open circuit.

(2) Inspect the wiper-closing relay (relay M in typical connector circuits) for dirty contacts or insufficient spring tension. Clean and adjust as required.

(3) Inspect all other connector relays involved in the ring-back tone circuit. Refer to the manufacturer's circuit diagram for their designation and location. Clean and adjust relay contacts as required.

e. CALLING PARTY CANNOT HEAR CALLED PARTY.

(1) Test the *called* line from the test desk. If a satisfactory talking test proves the outside plant equipment is not at fault, make routine tests of the connectors in the group serving the *called* line.

(2) Inspect the relays in each connector transmission circuit for dirty contacts and improper spring tension. Clean and adjust relay contacts as required. Inspect the battery-reversing relay (relay D in typical

connector circuits). Test to make sure that battery is supplied to the *called* line and the *calling* line.

(3) Test the operation of the line relay associated with the *called* telephone line. Be sure that the relay operates completely in its second step and frees the line from any attachments.

(4) Inspect the distributing frame wires in the *called* telephone circuit for loose or poorly soldered connections.

f. Called Party Cannot Hear Calling Party.

(1) Test the *calling* line from the test desk. If a satisfactory talking test proves the outside plant equipment is not at fault, make routine tests of the connectors in the group serving the *called* line.

(2) Test the battery-reversing relay, making sure that battery is transmitted to the *calling* line. Inspect the relays that complete the transmission circuit for dirty or corroded contacts and improper spring tension. Clean and adjust as required.

(3) Test the operation of the line relay associated with the *calling* line. Inspect the contacts for dirt, corrosion, or improper adjustment. Be sure that the relay operates completely in its second step and frees the line from any attachments.

(4) Inspect the distributing frame wires in the *calling* line circuit for loose or poorly soldered connections.

g. Calling Party Receives Busy Tone Before Completion of Dialing. This complaint should be infrequent, and is usually due to a heavy calling rate, causing all trunks to be busy in certain switch groups. Busy tone then might be received before dialing the second or third digit. Check the reported switch groups to make sure that no fault or trouble is tying up some of the switches. Advise the telephone user of the reason for the condition. Suggest a short waiting period, when this condition occurs, before attempting to place the call again. Keep all units at best operating efficiency so that service interruptions are not caused by the step-by-step dial central office equipment. If this condition occurs frequently, some lines might have to be cross-connected to different linefinder groups to obtain better distribution of traffic.

h. Calling Party Receives Continual Busy Tone. This complaint may result from a short-circuited line or from a handset left off the cradle.

i. Noisy, Intermittent, or Poor Transmission. A talking circuit normally is completed through several pairs of switch bank contacts and wipers, and many pairs of relay contacts. When the above complaint is caused by the step-by-step dial central office equipment, it may be due to these connections. Inspect the following:

(1) Worn wiper tips. As the tips wear, the wiper spring tension decreases unless the tension is adjusted. Replace the tips before a notch is worn in the tip or the tip edges become feathery.

(2) Defective wiper cords. Test the cord for broken conductors by bridging a test receiver across the ends while the cord is carrying current. Move the cord and twist it slightly while listening for noise. Replace the cord when noisy or if its condition is doubtful.

(3) Dirty switch bank contacts. Clean with the bank cleaning tool and cotton sleeving to remove dirt or gummy deposits.

(4) Dirty, corroded, or pitted relay contacts or improper contact spring adjustment. Check and clean as required. Verify the contact spring tension after cleaning. Adjust when necessary (pars. 59 and 60).

(5) Carbon protector blocks on the CDF (MDF). The discharge of a high potential from the line to ground may have caused a high-resistance ground. Replace the block if grounded. Clean all dirt and dust from the protectors.

(6) Distributing frame wiring, shelf wiring, and bank cables. Look for loose or poorly-soldered connections. Resolder if in doubt.

(7) The 2-mf (microfarad) capacitors in the transmission circuit of the connector switch. Test for leakage or intermittent open circuit, using the volt-ohm-milliammeter on the high-ohm scale. Replace with new capacitors if in doubt.

(8) Insulation leakage or intermittent contact in cables, terminal boards, contact banks, coils, or resistors. Make an insulation resistance test in the noisy or intermittent circuit. Check any induction coils, repeating coils, or resistors for partial short circuits or intermittent open circuits.

j. Called Telephone Does Not Answer. Failure of a called telephone to answer may be caused by an open ringer circuit in the telephone set, open-

circuited or grounded lines, or defective connectors in the step-by-step dial central office.

(1) Make routine tests of the connectors serving the reported line.

(2) A short-circuited line or a ground on the negative (−) (ring) side of the line will be indicated by a permanent signal on a first selector supervisory panel. Remove the heat coils from the troubled line at the CDF after verifying the short-circuited or grounded condition.

(3) An open telephone ringer or open-circuited line can be tested and verified from the central office test desk.

(4) A handset left off the cradle will cause a linefinder permanent and operate the signal on the associated first selector supervisory panel. After verifying this condition from the central office test desk, connect the howler circuit to the line under test. If attention cannot be attracted at the telephone set, remove the heat coils from the line and report the line in trouble. Send a repairman to check the outside plant equipment.

k. Telephone Set Bell Does Not Ring.

(1) When this trouble is found not to be in the outside plant, connect the connector routine test set (fig. 13) to the test jacks of the connectors serving the group of lines in which the fault is located, and completely test each connector. A defective connector that fails to ring the called line may be frequently seized by calling lines, causing service interruption and trouble reports.

(2) If ringing current is not being supplied to any of the connector switches on the shelf under test, check to see that the generator toggle switch (GEN) on the shelf supervisory panel is in the ON position.

(3) When ringing current is being supplied to a connector which fails to apply it to the called line, check its ringing circuit and relays for operation. Inspect the relay make contacts for dirt and insufficient spring tension. Clean and adjust as required.

(4) Inspect other connector relays and relay contacts used to complete the ringing circuit. Refer to the manufacturer's circuit diagram for their designation and location. Clean and adjust relay contacts as required.

(5) If the connector switch is functioning properly and the trouble condition still exists, dial the called line from the test desk; ring the line for a recheck; and examine the connector cross-connections, shelf wiring, bank cables, and bank contacts.

45. Trouble-Shooting Charts

A trouble-shooting chart assists in understanding causes and effects of central office equipment troubles. The following charts list common troubles and symptoms in typical step-by-step dial central office equipment. A trouble-shooting chart made for each central office, covering the specific equipment used in that office, is a valuable aid in training maintenance personnel. Unusual troubles, their symptoms, and their correction can be added to the chart so that future troubles may be readily found by others.

a. Troubles Indicated by Supervisory Signals.

Symptoms	Probable troubles	Corrections
Fuse alarm operates on power distributing fuse panel.	Short circuit or overload in power circuits.	Test circuit for trouble. Repair equipment and replace power fuse and alarm fuse.
	Defective alarm fuse.	If power fuse was not blown, replace alarm fuse.
Motor-generator control panel fuse alarm operates.	Open charging fuse or fuses.	Clear trouble in circuit, if any. Replace fuse and associated alarm fuse.
	Defective alarm fuse or fuses.	Replace alarm fuses.
	Open reverse-current relay fuse.	Test relay circuit and replace fuse.
Main battery fuse alarm operates.	Open main fuse.	Clear trouble in circuit, if any. Replace main fuse and associated alarm fuse.
	Defective alarm fuse.	Replace fuse.

Symptoms	Probable troubles	Corrections
Voltage alarm operates because of low voltage.	Main battery discharge or failure.	Check battery cells. Adjust motor-generator controls to charge battery.
	Motor-generator voltage too low.	Adjust generator voltage controls.
	Motor-generator paralleling panel fails to start No. 2 machine.	Check control circuits and motor generator.
	End-cell control switch fails to switch end-cells into main battery circuit.	Clean and repair end-cell control switch.
	Open LV relay coil or resistor, or contact springs out of adjustment.	Replace relay coil or relay. Adjust contact springs.
Voltage alarm operates because of high voltage.	End-cell control switch fails to switch end-cells out of main battery circuit.	Clean and repair end-cell control switch.
	Generator voltage too high.	Adjust generator control.
	Motor-generator control panel fails to cut No. 2 machine out of circuit when power load diminishes.	Check control circuit and relays.
Ringing current supervisory alarm operates steadily.	No. 2 ringing machine fails to start automatically when No. 1 machine shuts down.	Clean contacts on transfer relays. Test transfer relays.
		Test automatic starting switch.
		Clean ringing machine commutator.
		Replace commutator brushes.
	Generator hold-up relay (GEN HU) fails to operate.	Replace the relay coil or relay.
Supervisory fuse alarm operates.	Open fuse or fuses in ringing, tone, or signal circuits.	Remove open fuse. Check circuit and clear trouble. Replace fuse.
Group fuse alarm operates.	Open fuse or fuses on shelf fuse panel.	Remove open fuse. Check circuit and clear trouble. Replace fuse.
Release alarm operates.	Linefinder, connector, or selector failed to restore to normal position when released.	Restore switch manually. Busy out the defective switch. Repair, test, and place in service.
CDF lamps operate.	Operated heat coil or coils.	Test and clear line. Replace heat coils.
Permanent signal (PERM) on connector shelf.	*Called* party fails to disconnect.	Locate affected switch. Challenge on the line. Test line and use howler. Open the line by removing the heat coils. Fill out trouble report.
	Calling party fails to disconnect.	Same as above.
	Short circuit or ground appears on line after connector has seized it.	Test as above. Open line by removing heat coils. Fill out trouble report.
ST SIG lamp glows on linefinder shelf and alarm buzzer operates.	Linefinder fails to step from normal position and hunt for calling line.	Locate faulty switch. Operate busying switch to remove faulty switch from the circuit. Repair the switch, test, and replace in service.
	Defective relay A–3 in group relays.	Clean and adjust contacts.
Supervisory signal lamp (SUPY) glows on selector shelf.	*Calling* party fails to dial or hang up after selector switch has been seized.	Challenge seized line. Test line and use howler. Fill out trouble report. Dispatch repairman to telephone set in question.

b. TROUBLES INDICATED BY SERVICE COMPLAINTS.

Symptoms	Probable troubles	Corrections
Noisy, intermittent, or poor transmission.	Wiper tips worn too thin.	Replace wipers.
	Insufficient tension on wiper tips.	Adjust wiper spring tension.
	Broken conductors in wiper cords.	Replace cords.
	Dirty switch bank contacts.	Clean switch bank contacts.
	Dirty relay contacts or insufficient contact spring tension.	Clean relay contacts. Adjust contact spring tension, if required.
Cannot make outgoing calls.	All trunks busy.	Instruct user to place call later.
	Linefinder or connector permanents, or off-normals.	Clear troubles and restore blocked switches.
	Defective telephone line equipment.	Repair defective line equipment.
	Defective line relay coil.	Replace relay coil.
	Line relay contacts not making.	Clean relay contacts. Adjust contact spring tension, if required.
	Open resistor in linefinder start circuit.	Replace the resistor.
	Fault in group relay circuit.	Check group relays.
Calling party does not receive dial tone.	Rotary cam springs on first selector not making contact.	Clean and adjust cam spring contacts.
	Selector relay contacts not completing dial tone circuit.	Inspect for dirty or pitted contacts. Clean and adjust.
	All linefinders in group busy.	Advise telephone user to restore handset and to place call again.
Calling party does not receive busy tone.	Connector relay contacts not completing busy tone circuit.	Inspect for dirty or pitted contacts. Clean and adjust.
	Open capacitor in busy tone circuit.	Replace the capacitor.
Calling party receives busy tone before completion of dialing.	All trunks busy.	Check trunks for possible trouble. Advise telephone user to place call at less busy time.
Calling party does not receive ring-back tone.	Connector relay contacts not completing ring-back tone circuit.	Inspect for dirty or pitted contacts. Clean and adjust.
	Open capacitor in the ring-back tone circuit.	Replace the capacitor.
Bell does not ring.	Open-circuited or short-circuited line crossed with battery.	Test the line from the CDF.
	Open-circuited ringer.	Dispatch repairman to the telephone set.
	Ringing current not being supplied to the line.	Check operation of the ringing group relays. Check each connector ringing relay in group. Clean and adjust relay contacts, if required.
Called party does not answer.	Same as above.	Same as above.
Calling party cannot hear *called* party.	Connector relay contacts not completing transmission circuit.	Make routine test of connectors. Inspect, clean, and adjust relay contacts.
	Reverse-battery relay does not supply battery to *called* party.	Inspect, clean, and adjust contacts.
	Open capacitor or capacitors in connector transmission circuit.	Replace the capacitors.
	Relay contacts faulty in preceding switches.	Test selectors, line finders, and line relays.
Called party cannot hear *calling* party.	Relay contacts on connector preceding switches not completing transmission circuit.	Make routine test of connectors. Inspect for dirty or pitted relay contacts. Clean and adjust.
	Reverse-battery relay does not supply battery to *calling* party.	Check, clean, and adjust contacts.
	Open capacitor or capacitors in transmission circuit.	Replace the capacitors.
	Relay contacts faulty in preceding switches.	Test selectors, line finders, and line relays.

CHAPTER 4

ADJUSTMENTS AND REPAIR

Section I. ADJUSTMENTS

46. Two-motion Stepping Switches (figs. 21 and 22)

a. Most faults occurring in two-motion stepping switches can be corrected by readjusting the stepping mechanism and the relays. Certain minor adjustments can be made while the switch is in its working location on the shelf. Operate the busying switch, if provided, before adjusting. However, whenever feasible, remove the switch from the shelf even for

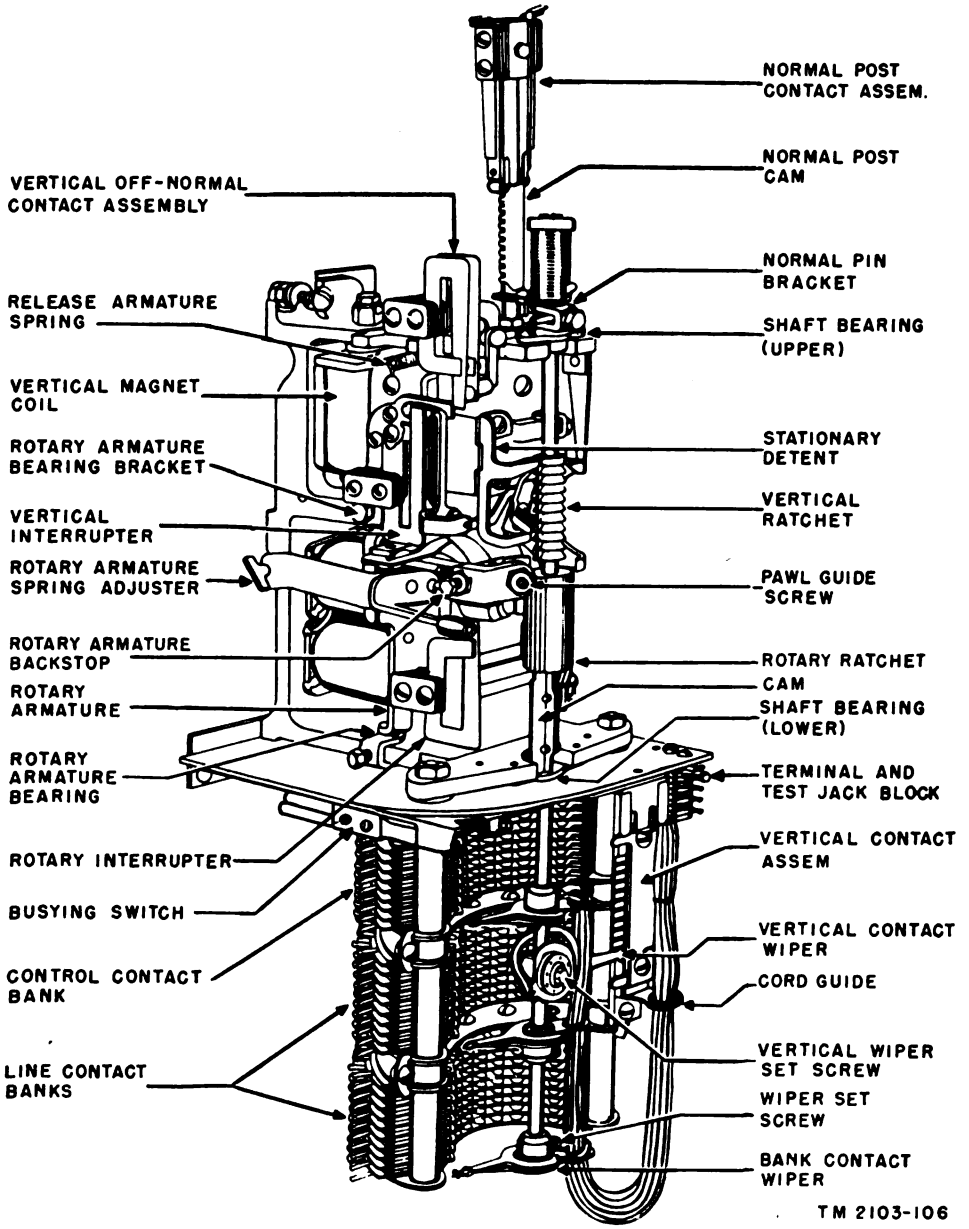


Figure 21. Typical two-motion stepping switch, left side.

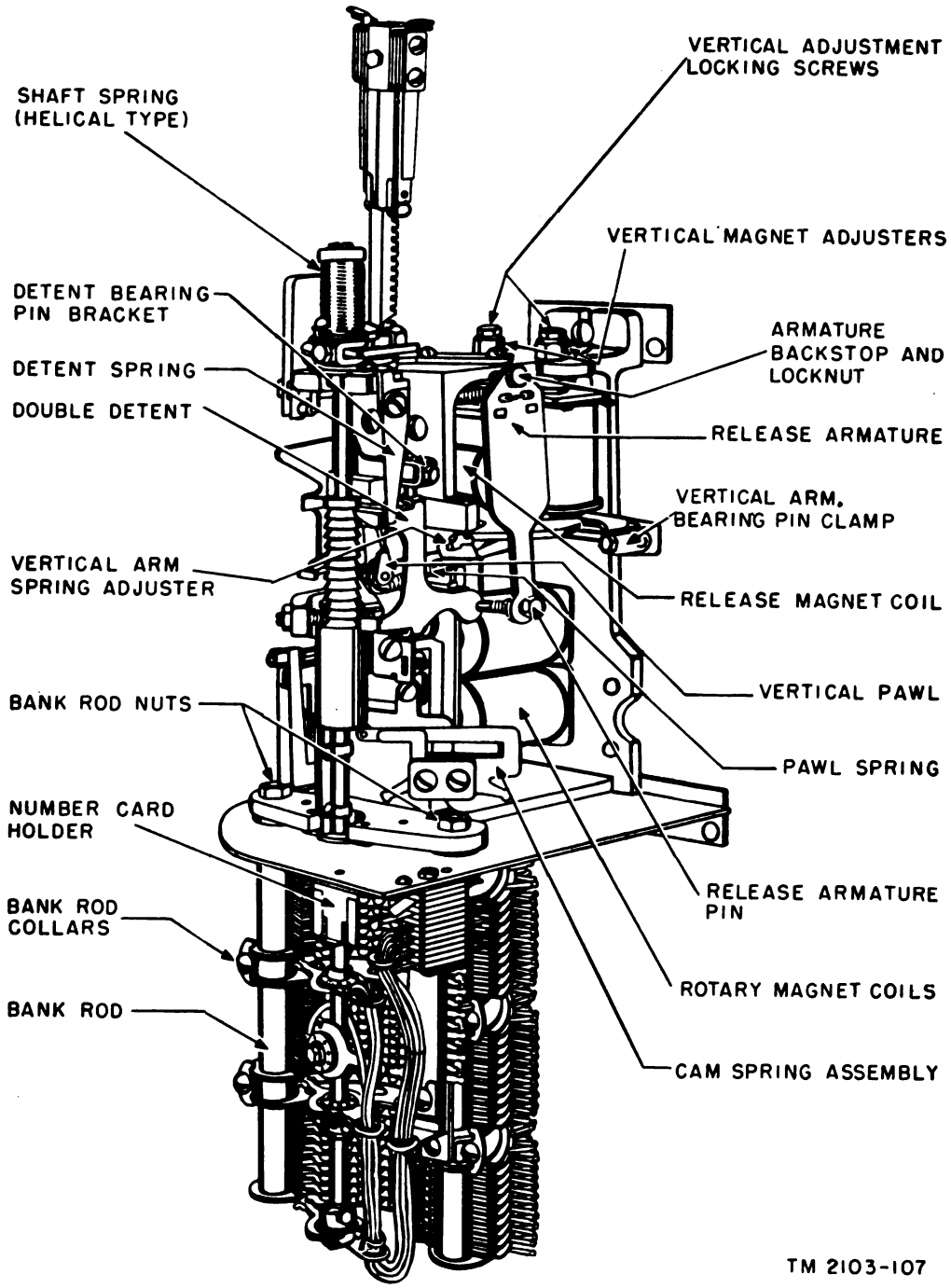


Figure 22. Typical two-motion stepping switch, right side.

minor adjustments, and place it on the test stand (Auto Elec H–15979) (fig. 24). Locate the test stand on a properly equipped and well-lighted repair bench. A 24-terminal test jack similar to the shelf jacks is provided on the test stand. Connect terminals 11 and 12 of this connector to the positive and negative terminals of the central office battery.

b. Inspect the switch thoroughly, examining each part for signs of wear or failure. Check the adjustment of each part, as specified in paragraphs 48 and 49.

Note. Tolerances or inspection limits are listed for some of the adjustments in the following paragraphs. If the part falls within the inspection limits, do not adjust. Adjust to the *adjust* value only if the inspection limits are exceeded. *Perceptible* is used in this manual to agree with the meaning given it by the manufacturer. It does *not* mean one-sixty-

fourth inch. A *perceptible* clearance means a space or gap, too small to measure conveniently with a thickness gage, which is checked by operating the parts by hand to determine that there is no binding. A *perceptible* clearance can frequently be discerned, in a strong light, when holding a strip of white paper behind the parts. *Perceptible* as applied to contact follow means that the follow must be sufficient to be observed but that it is not to be measured.

c. When adjustments are made, recheck all other adjustment requirements that may be affected. Test the performance of each switch after adjustment, before returning it to service. Use the routine test equipment (pars. 28 to 35).

47. Removing and Replacing Switches

a. Removing Switch From Shelf (fig. 23). Remove the switch cover. If the switch has a vertical commutator mounted on the switch bank, remove the wiper cord guide from the commutator bracket. Remove the bank rod nuts to release the switch bank from the switch. Place the right hand under the lower cover plate. Press upward on the switch until the shelf pins engaged in the slots in the switch mounting base are opposite the slot openings. At the same time, hold the switch bank stationary with the left hand, pressing the bank toward the shelf frame to prevent catching the switch wipers on the bank contacts. Pull the bottom of the switch slightly forward. Release the bank, tilting the lower part forward to avoid damaging the wipers. Place the left hand on the top of the switch to steady it and draw the switch forward free of the shelf. Support the weight of the switch by pressing upward with the right hand under the lower cover plate.

b. Replacing Switch on Shelf (fig. 23). Before replacing the switch, clean the shelf jack springs, and the male contacts on the switch. Grasp the switch, holding it as shown in figure 23. Tilt the top of the switch toward the shelf until the openings in the bayonet slots are opposite the shelf pins. Engage the top slots on the top shelf pins. Then support the switch bank with the left hand. Move the lower part of the switch towards the shelf until the full length of the mounting plate rests against the shelf. Lower the switch slowly until the shelf pins come into contact with the end of the slots. Guide the bank rods into the holes in the switch frame. Replace and tighten the bank rod nuts.

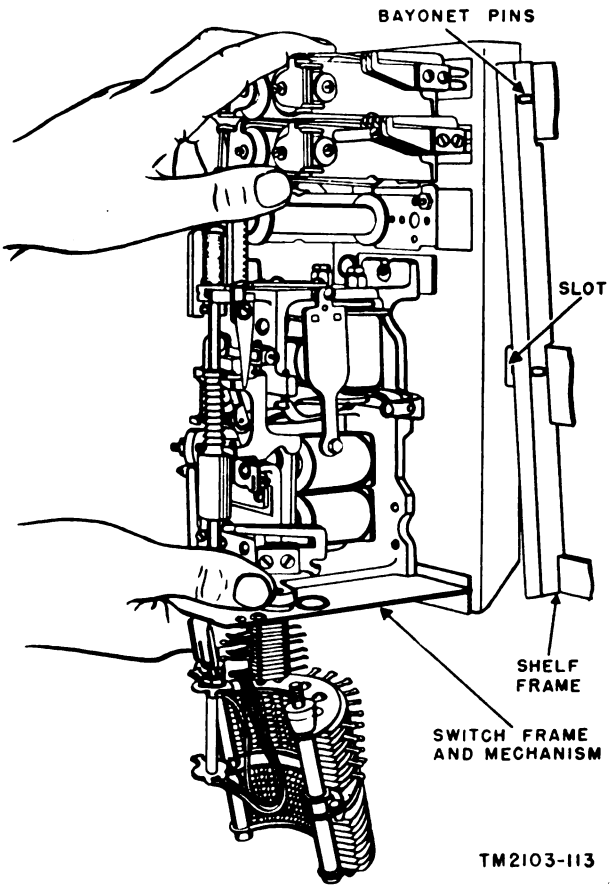


Figure 23. Removing or replacing two-motion stepping switch on shelf.

48. Requirements and Adjustments for Two-motion Stepping Switches

a. Switch Shafts (fig. 25).

(1) Check the helical-type shaft spring, making sure it has sufficient tension to restore the switch shaft to its normal position from any rotary step on each level. One and one-half complete turns in a clockwise direction will usually be satisfactory.

(2) The switch shaft when released must restore to its normal position from any vertical position by its own weight, and must restore the off-normal switch on its return to normal. The switch shaft is considered to be in the normal position when the normal pin bracket is resting on the upper switch shaft bearing. If the switch shaft fails to restore, inspect for a bent or scored shaft, lack of lubrication, or misalinement of the switch shaft bearings.

(3) Rotate the switch shaft to the tenth position on the first level. There should be perceptible clearance between the normal pin bracket and the off-normal lever.

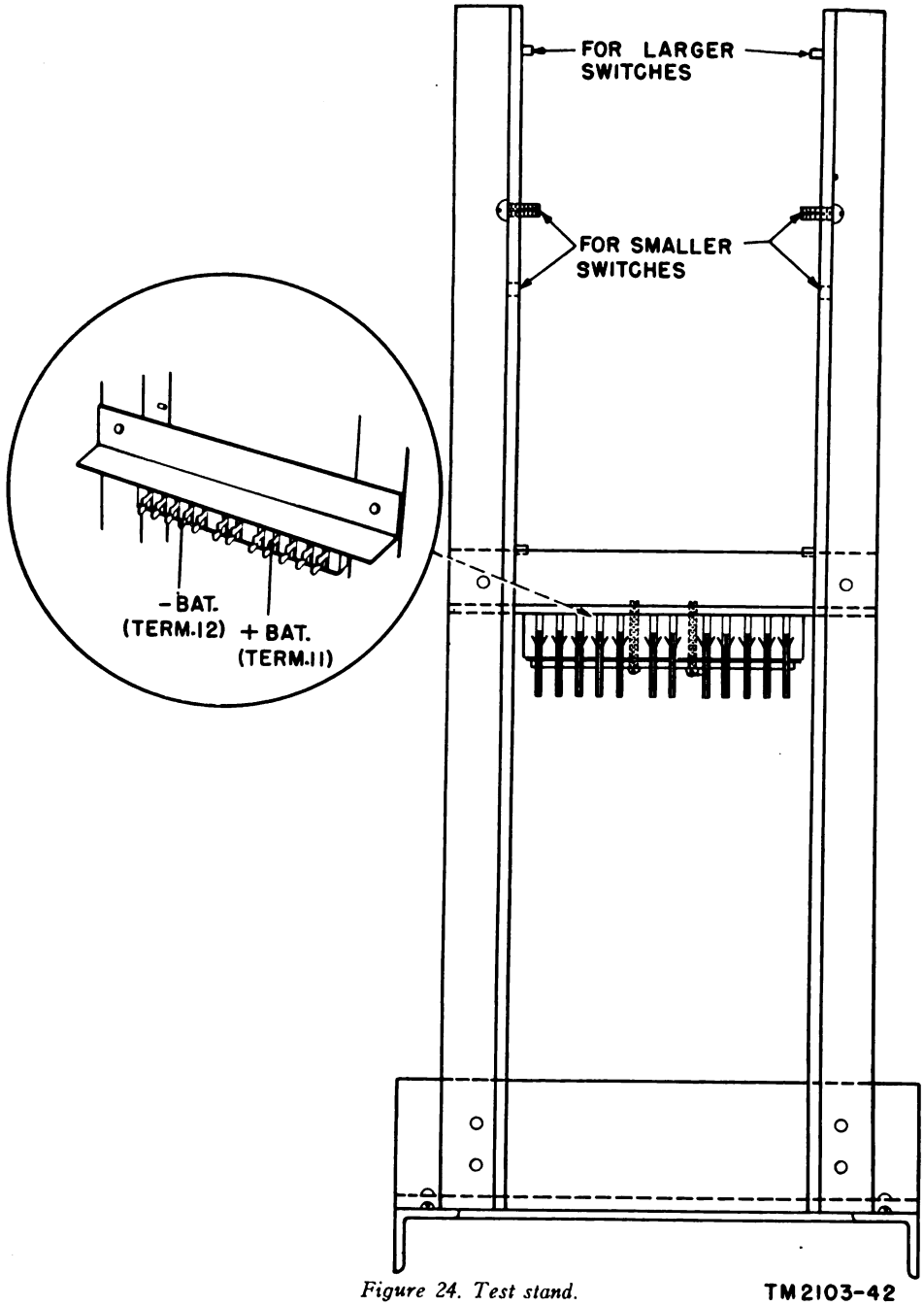


Figure 24. Test stand. TM2103-42

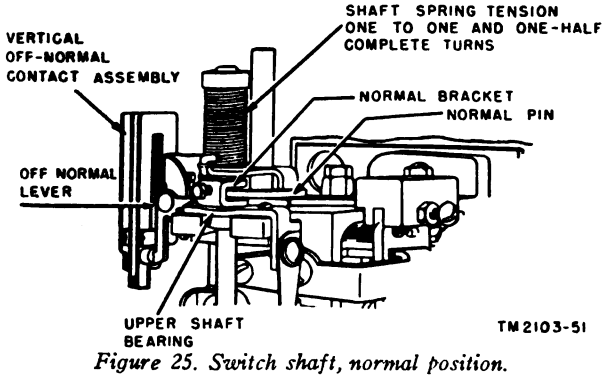


Figure 25. Switch shaft, normal position.

b. VERTICAL STEPPING MECHANISM (figs. 26 and 27). Check the vertical stepping mechanism in the following sequence:

(1) Be sure the vertical magnet armature moves freely. The maximum allowable side play is 0.012 inch.

(2) Be sure the vertical armature restoring spring has sufficient tension. The tension, measured at the T-head spring adjusting

screw, should be not less than 150 grams. Increase or decrease the tension by moving the screw out or in.

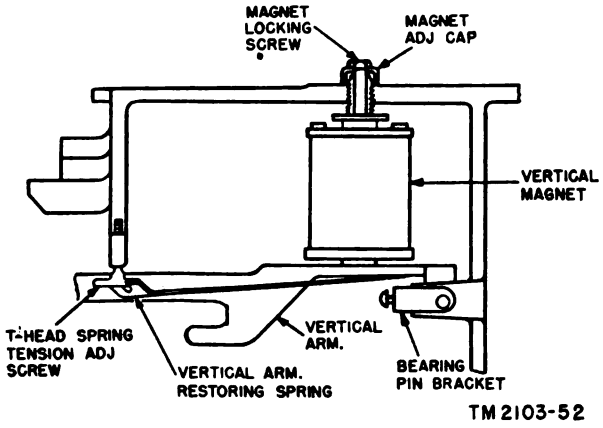


Figure 26. Vertical magnet mechanism.

(3) The vertical armature should strike both magnet cores when the vertical magnet is electrically operated, or it should have not more than 0.002 inch space between the armature and the closest point on one but not both cores.

(4) There should be perceptible play between the vertical pawl and the switch frame (overthrow stop) with the vertical magnets electrically operated, and with the vertical pawl engaged with the vertical tooth corresponding to each operating level. There should be a gap between the top of the vertical detent and the under surface of the vertical tooth which should not exceed 0.010 inch when the switch shaft is raised by hand and the vertical pawl is resting against the overthrow stop.

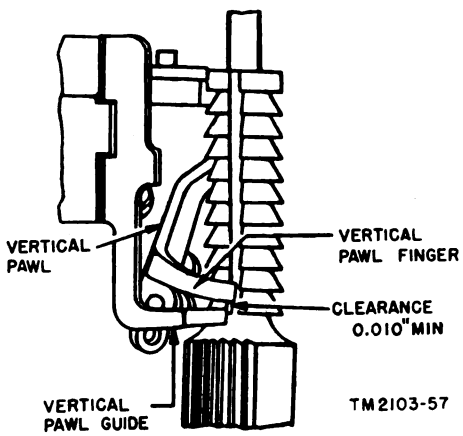


Figure 27. Vertical pawl.

(5) Adjust the gap to meet the above requirements by shifting the position of the vertical magnets on the switch frame. Loosen the magnet locking screw. Turn the magnet adjusting cap until the requirement has been met. Tighten the locking screw.

(6) The vertical pawl must not bind on its pin. Its maximum side play with relation to the vertical magnet armature should not exceed 0.008 inch.

(7) The minimum clearance between the vertical pawl finger and the vertical pawl guide (fig. 27) should be 0.010 inch at the point where the switch shaft starts to move vertically under control of the vertical armature at all operating levels.

(8) The vertical pawl must clear the vertical ratchet teeth (fig. 28) as the switch shaft releases, and must clear the rotary ratchet when the switch shaft is raised to the tenth operating level (fig. 28).

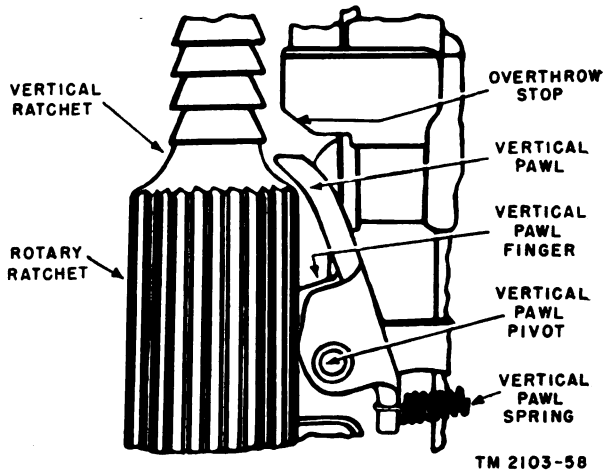


Figure 28. Vertical pawl after the tenth step.

(9) Both corners formed by the arc in the vertical pawl tip should contact the shoulder of the tooth with the pawl advanced above and resting on the shoulder of the first tooth.

(10) The opening in the loop of the pawl spring after it is attached to the pawl should not exceed five-sixty-fourths inch.

c. Rotary Stepping Mechanism (figs. 29 and 30). Check the rotary stepping mechanism in the following sequence:

(1) The rotary magnet armature must pivot freely on its pin, with a maximum vertical

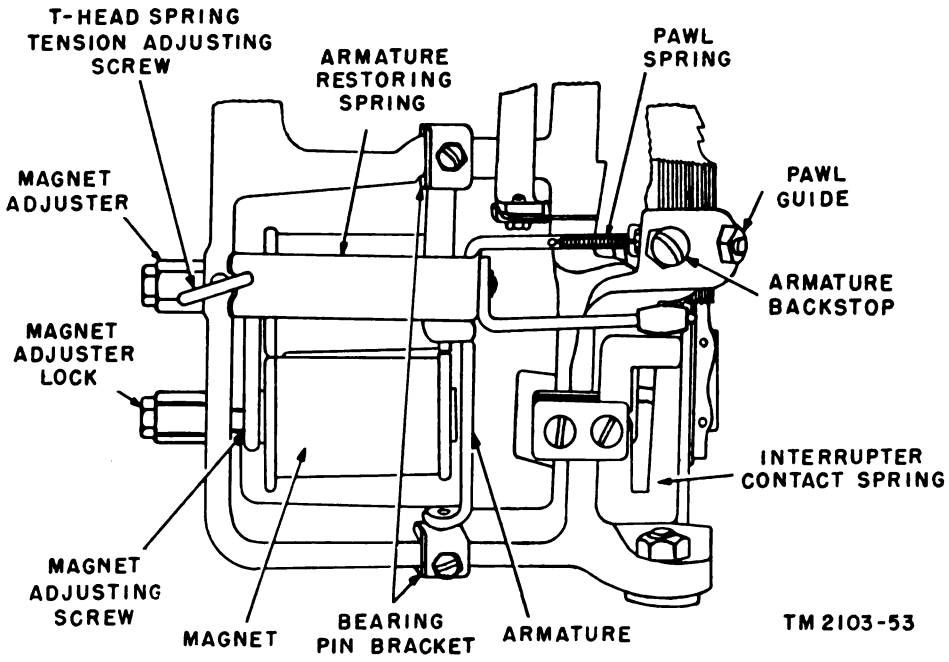


Figure 29. Rotary magnet mechanism.

play of 0.003 inch. In its nonoperated position, the armature should overlap at least two-thirds of the diameter of the backstop screw. The rotary pawl should completely overlap the end of the rotary pawl guide.

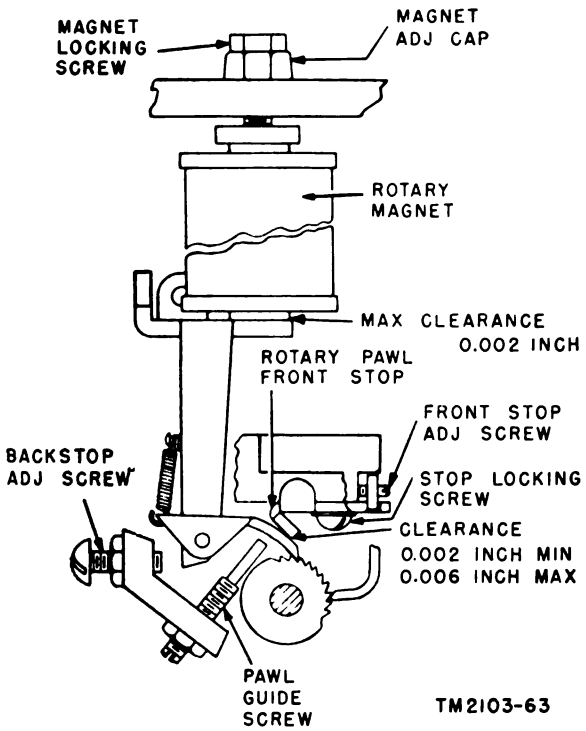


Figure 30. Rotary pawl mechanism.

(2) The tension of the rotary armature restoring spring, measured at the T-head spring adjusting screw, should be not less than 150 grams. Increase or decrease the tension by moving the screw in or out.

(3) The rotary magnet armature should strike both magnet cores at the same time when the magnets are electrically operated, or should have not more than a 0.002-inch space between the armature and the closest point on one but not both cores.

(4) With the rotary magnets energized, and not warmer than room temperature, the minimum clearance between the rotary pawl and its front stop should be 0.002 inch while the maximum clearance should be 0.006 inch. Check the clearance at the first, fifth, and tenth rotary steps on the fifth bank level.

(5) Set the rotary armature stop to allow the shaft to release from any level without striking the pawl, and to have from 0.002 inch to 0.010 inch clearance between the pawl and the shaft, with the shaft at normal. The opening in the loop of the pawl spring after it is attached to the pawl should not exceed five-sixty-fourths inch.

(6) Raise the switch shaft to the first operating level and advance it to the first rotary

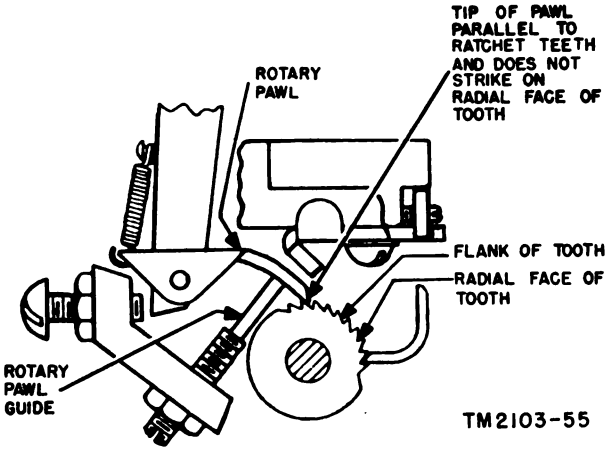


Figure 31. Rotary pawl adjustment.

position. Advance the rotary pawl until it strikes behind the second tooth (the eighth tooth counting from the rotary detent). The rotary pawl guide screw must be set so that the pawl either strikes against the base of the second tooth or slides slightly on the flank of the preceding tooth to the base of the second tooth. The rotary pawl must not strike on the radial face of a tooth and then slide to the base. If adjustment of the rotary pawl guide screw fails to correct improper striking of the pawl on the rotary teeth, return the switch shaft to its normal rotary position but be sure it remains on the first vertical level. Loosen the normal pin bracket setscrew slightly. If the rotary pawl strikes the radial face of the tooth, shift the normal pin to the left. If the pawl slides too far on the flank of the succeeding tooth, shift the normal pin to the right. With the pawl striking squarely at the base of the tooth, tighten the normal pin setscrew. Rotate the switch shaft step by step. Make sure that the rotary pawl strikes within the same limits on the succeeding teeth.

Note. If it has been necessary to move the normal pin, check the stationary detent to see that it clears the shaft teeth during vertical movement. Also check clearance of the wiper assemblies during vertical travel and correct positioning on the bank contacts during horizontal travel.

(7) Set the rotary armature backstop to allow the switch shaft to release from any level without striking the rotary pawl, and to have 0.002 inch minimum or 0.010 inch maximum clearance between the rotary pawl and switch shaft at normal position. Make this adjustment with the shaft up five levels and in 10 rotary steps.

d. DETENTS (fig. 32). The double detent (sometimes termed "double dog") consists of an upper and lower detent. The upper (vertical) detent engages the teeth of the vertical ratchet of the switch shaft and the lower (rotary) detent engages the teeth of the rotary ratchet. A tension spring holds the detent against the shaft, but the detent is pivoted so that the release magnet armature strikes it when operated, and disengages the detent from the shaft. A stationary detent (sometimes termed "stationary dog") is located on the switch opposite the double detent. It consists of two arms: the upper arm riding in a slot in the vertical teeth of the shaft, and the lower arm acting as the vertical pawl guide.

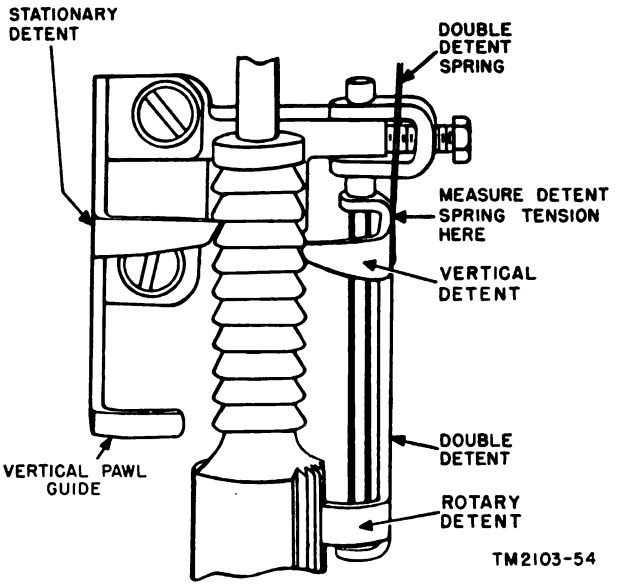


Figure 32. Double detent and stationary detent.

(1) The double detent must not bind on its pin nor have more than 0.002 inch vertical play. When engaged, the tip of the vertical detent should clear the notches in the vertical ratchet when the shaft is at rotary normal. It must engage freely on all levels and may allow a slight drop (0.003 inch) in the shaft on some levels, but not on all levels.

(2) With the shaft at rotary normal and the double detent disengaged from the release link, there should be a minimum of 0.002 inch or a maximum of 0.010 inch outside play of the switch shaft without moving the vertical detent (fig. 33). Adjust the verti-

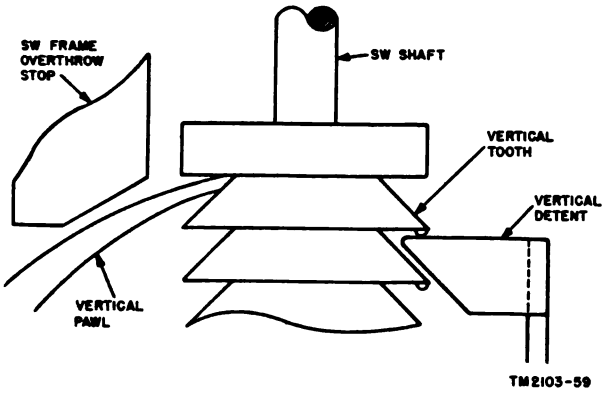


Figure 33. Vertical detent alinement.

cal detent to meet the requirement with the detent bender (Auto Elec H–7067) (fig. 33) while holding the entire assembly firmly with flat-nosed pliers. Check this requirement on all levels except the tenth. With the double detent engaged in the release link, the double detent spring should have a tension of at least 250 grams but not more than 400 grams measured just above the detent.

(3) The double detent spring should be free from unnecessary bends and have not more than 0.025 inch bow. The vertical center line of its broad surface must be approximately parallel to the shaft.

(4) The stopping face of the rotary detent should engage as flatly as possible with the radial face of the rotary ratchet teeth. Aline the rotary detent vertically when it rests on a ratchet tooth, so that a 0.002-inch gage will not enter between the tip of the detent and the tooth.

Note. Do not bend the rotary detent. If these specified requirements are not met, replace the double detent.

(5) The stationary detent should be adjusted to a 0.003-inch maximum clearance in the vertical ratchet slot at the nearest point when the normal bracket is pressed against the normal post from the left.

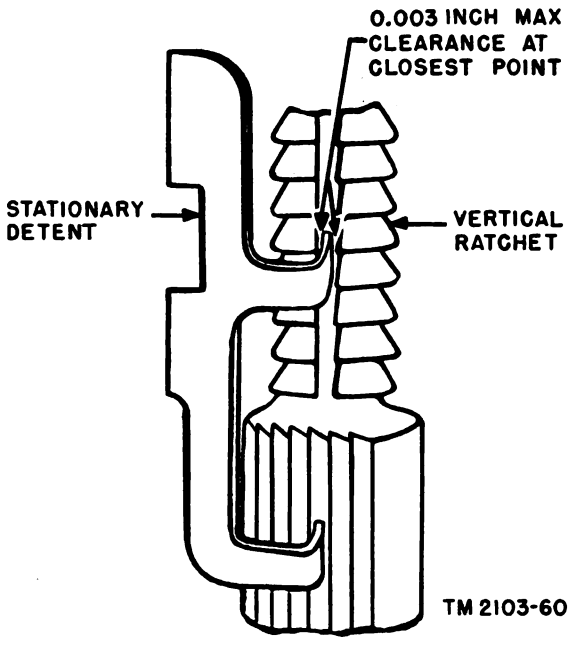


Figure 34. Horizontal alinement of stationary detent.

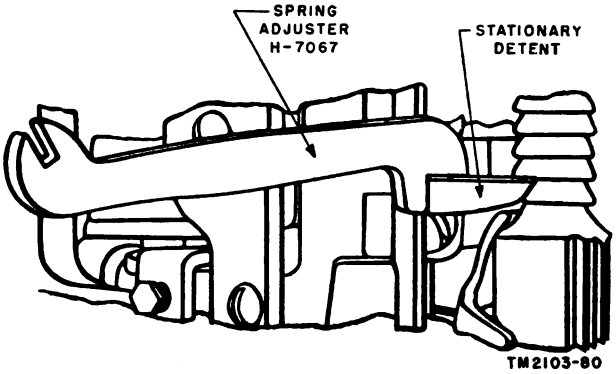


Figure 35. Adjusting stationary detent.

(6) The stationary detent must not cause a perceptible rise and should not allow more than a perceptible (0.003 inch) drop of the shaft as it engages on at least one level. The shaft must rest on the stationary detent with the rotary magnets energized on the first rotary step so that the vertical detent will engage fully when it is moved away from the shaft and allowed to drop back into position.

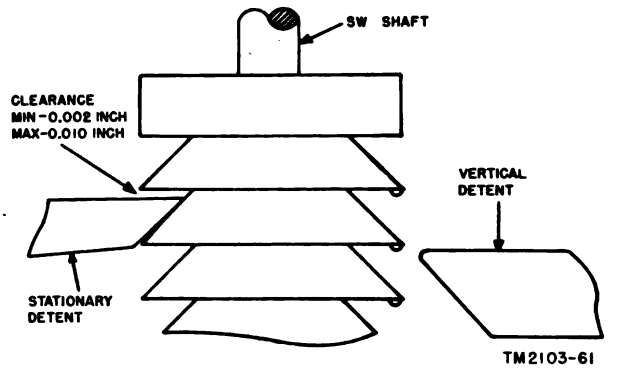


Figure 36. Stationary detent clearance.

(7) The stationary detent must allow a 0.002-inch minimum or a 0.010-inch maximum vertical movement of the shaft with the shaft stepped in two or more steps on any level. Make this test with the double detent held away from the shaft.

e. RELEASE MECHANISM (fig. 37).

(1) Raise the switch shaft to the fifth operating level. Clearance between the engaging edge of the rotary detent and the outer edge of the rotary teeth should be a minimum of 0.030 inch, or a maximum of 0.045 with the tooth of the double detent engaged in the release link.

(2) With the release magnet armature in its electrically operated position, the dowel-type adjusting screw in the release armature must operate the double detent far enough so that the release link drops completely over the tooth on the double detent.

(3) Place a 0.006-inch gage between the release magnet core and the armature, then energize the magnet. The release link must not engage the double detent tooth. Set the armature adjusting screw to meet this requirement.

(4) Adjust the release magnet armature backstop screw to allow a minimum clearance of 0.060 inch or a maximum clearance of 0.120 inch between the double detent and the end of the armature adjusting screw with the release armature at normal, the switch shaft at rest in any off-normal position, and the rotary detent engaged with the rotary teeth.

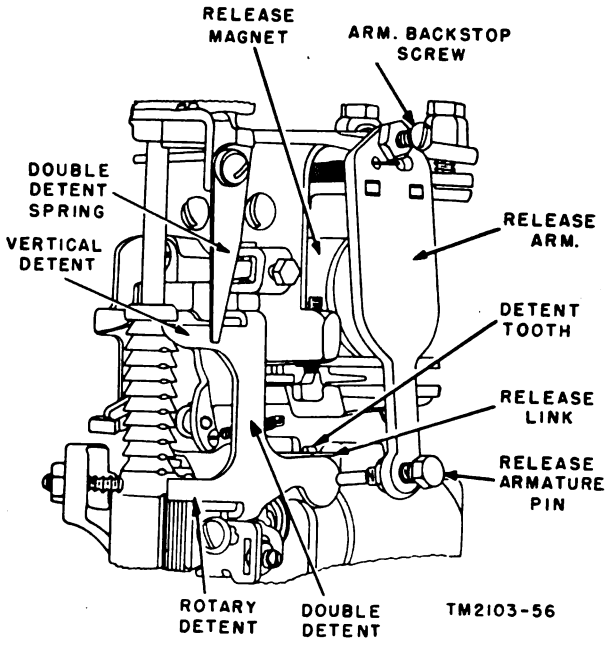


Figure 37. Release mechanism.

(5) The release magnet armature must operate the double detent and release the switch shaft from any position with current flow of 0.180 ampere, and release the armature when the circuit is opened. The magnet must release the armature on open circuit, after having been operated on a current of 0.365 ampere.

DIM.	CONTROL WIPER	LINE WIPER
A	0.125 IN.	0.125 IN.
B	ZERO	0.015 IN.
C	0.015 IN.	ZERO

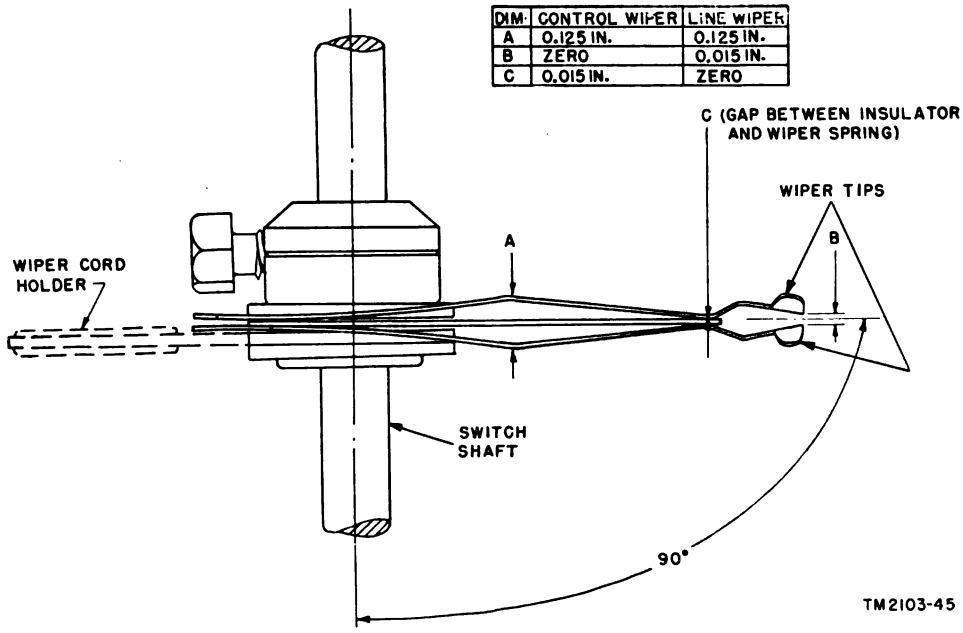


Figure 38. Wiper assembly, side view.

49. Bank Contact Wiper Assemblies and Switch Banks

a. The springs of the wiper assembly (fig. 38) must be at an angle of exactly 90° with the switch shaft. The upper and lower wiper tips should rest at equal angles on the switch bank contacts, and should be in vertical alinement with each other at their tip ends. At the point where the straight portion of the wiper spring forms into the wiper hub, the springs should have a sharp bend (springs should be about one-eighth inch apart), and should converge in a straight line to the end of the insulator.

(1) In the unoperated position, the tip ends of line wiper springs should be separated by approximately 0.015 inch. The springs of control wipers on 100-point switches should touch at their tip ends, unless otherwise specified. Check the wiper tips carefully for wear as this directly affects the above wiper tip spacing adjustments. Adjust the wiper tips to the above requirements, when necessary, by bending them close to the tip with a pair of fine long-nosed pliers. Do not flatten the wings on the tips when bending the tips. If the wiper tips are worn enough so that the leading edges are thin and feathery, do not attempt to adjust them, but replace the wiper assembly. Wiper tips may also be adjusted with two spring adjusters (WECo 263), one to bend the tips, the other to hold the wiper spring and prevent its deformation.

Note. Line wipers refer to the wiper assembly engaging the lower switch bank for 100-point switches, and to the two lower wiper assemblies for 200-point switches. Control wipers refer to the wiper assembly engaging the upper switch bank. On 100-point switches, the control wiper must meet the requirements specified above. *On 200-point switches, the same type of wiper assembly is used for line and control banks, and both should meet the requirements specified above for line wiper assemblies.*

(2) Line wiper springs should touch the end of the insulator. Control wiper springs should have a clearance of approximately 0.015 inch between the springs at the end of the insulator.

(3) The tension of each wiper spring must be sufficient so that when the pressure of one spring of the pair is removed from the other, both springs should have a minimum follow of three-thirty-seconds inch and one spring a maximum follow of nine-sixty-fourths inch.

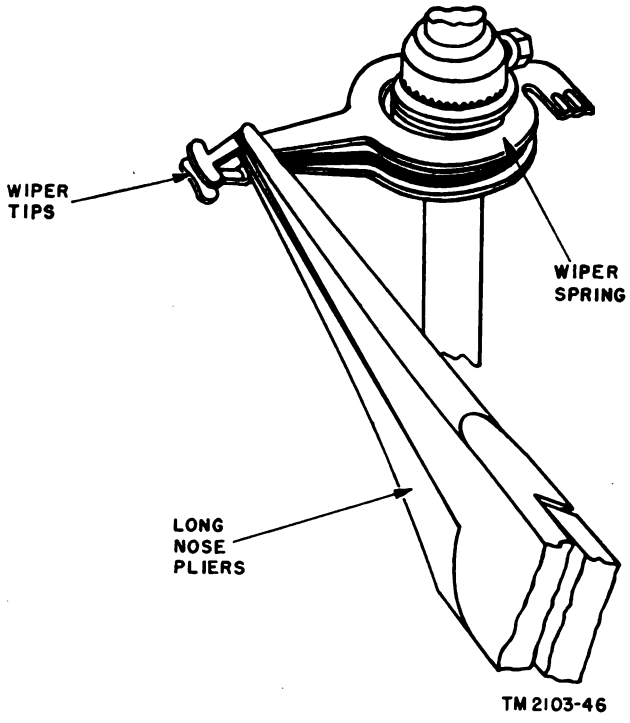


Figure 39. Adjusting wiper tip spacing.

(4) The point of contact of the wiper tips on each bank contact must be at least one-sixteenth inch from the end of the contact. Check on the first and tenth contacts of the first operating level.

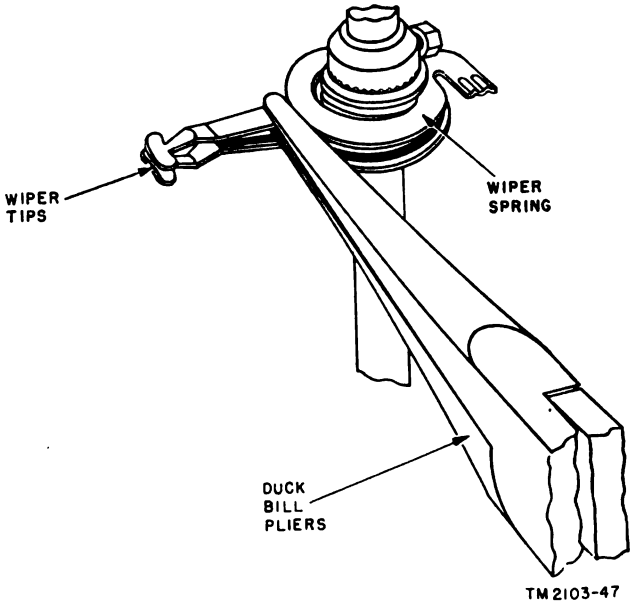


Figure 40. Adjusting wiper spring tension.

(5) The wipers should center on the fifth or sixth contacts of the first and tenth switch bank operating levels. Adjust by loosening the holding collar setscrew and rotating the wiper assembly in either direction until centered on the contact. Do not allow the wiper assembly to move horizontally on the switch shaft during the adjustment.

(6) If adjustment of the wiper assembly does not result in proper contact with the bank contacts in all positions, shift the position of the switch bank assembly. This is possible because the bank rod holes through the switch frame have more than normal required clearance. Loosen the two bank rod nuts slightly and carefully shift the switch bank assembly as required. Approximately three-sixty-fourths inch horizontal movement in any direction is possible. Readjust the wiper assemblies until the requirements are met.

(7) Apply a light pressure to the left side of the shaft restoring spring bracket to take up any play between it and the normal post. Raise the switch shaft manually to the upper limit of its vertical travel. The wiper assemblies must clear all contact levels during this check. Adjust for clearance by loosening the holding collar setscrews and rotating the wiper assemblies until clearance is obtained. Do not allow the wiper assemblies to move vertically on the switch shaft during the adjustment. Recheck centering adjustment ((5) above).

(8) The center line between the wiper tips must coincide within one-sixty-fourth inch with the center line of the fifth operating level of the associated switch bank (unless otherwise specified below), when the wiper is about to cut in on the first contact of that level. Adjust by loosening the holding collar setscrews and moving the wiper assembly vertically to meet the requirement. Do not allow the wiper assembly to rotate on the switch shaft during the adjustment.

(9) The switch bank rod collar assemblies must be tight and must hold the switch banks securely in place on the bank rods. The top bank should be in contact with at least one of the two bank rod assembly locating shoulders.

(10) Upon completing the wiper and switch bank inspections, and after making any necessary adjustments, test the restoring of the switch shaft and wipers from the eleventh rotary position to the normal position on the first and tenth levels. Manually operate the stepping mechanism. Press upward on the shaft when pressing the release magnet armature to trip the double detent, thus reproducing the same condition as when the vertical stepping magnet is energized. Test the electrical operation of the switch only after it has been tested manually.

b. Vertical Wiper Assemblies and Contact Banks (fig. 42). On switches equipped with vertical contact banks and wipers, the center line of the

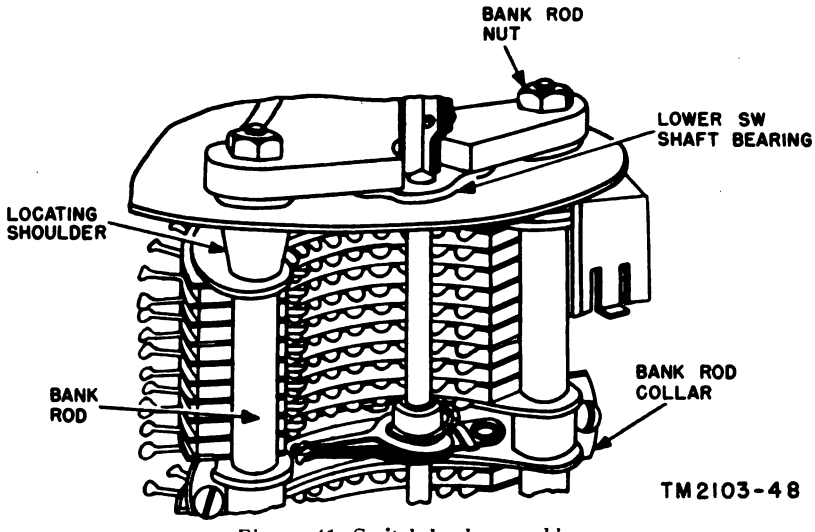


Figure 41. Switch bank assembly.

vertical wiper must be at a 90° angle with the switch shaft. The vertical contact bank must be mounted with its center line parallel with the switch shaft. During adjustment, the original form of the wiper tip must not be changed.

(1) The center line of the vertical wiper should be not more than one-thirty-second inch above nor more than one-sixty-fourth inch below the center line of the vertical bank contact corresponding to any horizontal level when the switch shaft is raised to that level.

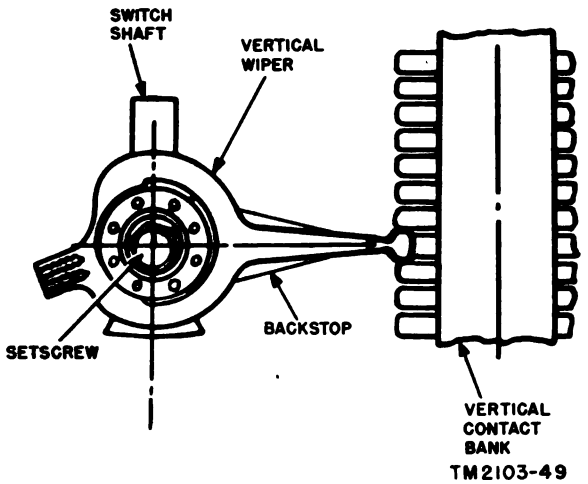


Figure 42. Vertical wiper assembly and contact bank.

(2) Only the tip of the wiper should rest on the bank contacts.

(3) The spring tension of the vertical wipers, measured at the offset between the straight portion and the tip, should be a minimum of 30 grams and a maximum of 45 grams.

(4) The tip of the vertical wiper should clear the vertical bank contacts on all levels when the switch shaft is advanced to the first rotary position.

(5) Raise the switch shaft to the first vertical position. Turn the shaft toward the first rotary position until the wiper backstop begins to lift the wiper tip from the vertical bank contact. At this point, the vertical wiper tip should overlap the bank contact by at least five-sixty-fourths inch.

(6) With the switch shaft at rotary normal on all levels, the vertical wiper backstop should clear the wiper. This provides full contact pressure between the wiper tip and bank contacts.

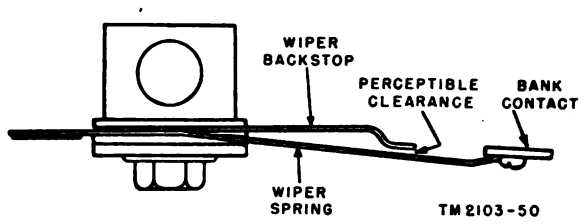


Figure 43. Vertical wiper, top view.

c. Wiper Cords (figs. 95 through 98). When properly installed, wiper cords normally remain in proper position. If wiper cords are displaced or disarranged during cleaning operations, rearrange and secure them (fig. 96).

(1) When removing or replacing a switch from the shelf, push the switch bank assembly back slightly after releasing it from the switch frame. This will prevent the displacement of the wiper cords and the bending of wiper assemblies.

(2) When lifting the switch shaft manually, raise it by operating the vertical armature by hand, or by placing a finger under the end of the switch shaft.

50. Stepping Switch Auxiliary Contact Assemblies

a. Vertical Off-Normal Contact Assemblies (fig. 44).

(1) Check the contact pressure and spring tension. Adjust by bending the vertical off-normal lever. Inspect, and, if necessary, ad-

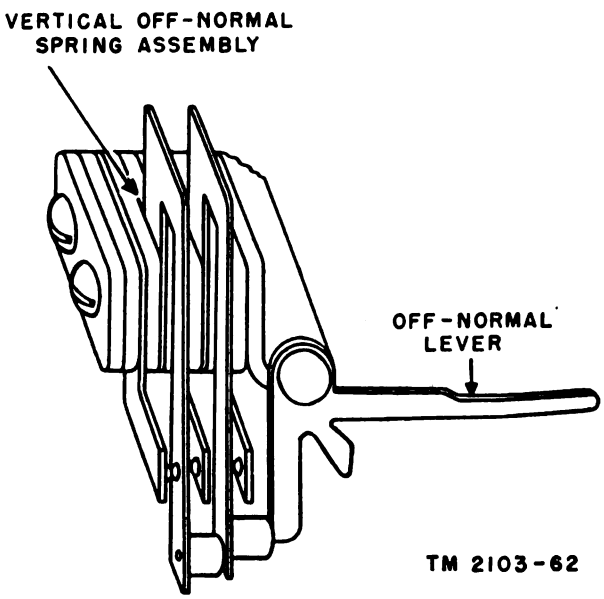


Figure 44. Vertical off-normal contact assembly.

just the clearance between the contact bumper and the first lever spring. Adjust by loosening the mounting screws with an offset screw driver and shifting the vertical off-normal bracket as necessary to obtain the adjustment. Inspect the clearance between the end of the off-normal lever and normal pin. Adjust the clearance by bending the tip of the off-normal lever.

(2) The minimum separation of contact springs should be 0.008 inch for make or break contacts. With the switch at normal, the springs should be approximately parallel with the shaft. The bumper on the off-normal lever should have perceptible clearance from the first lever spring with the off-normal lever in its highest position. This clearance should be as small as possible, otherwise binding between the normal stop pin and the off-normal lever might result. If a lever spring has an adjacent break contact, allow a minimum space of 0.002 inch between the spring bumpers when the shaft is off normal.

(3) Clearance between the off-normal lever and the normal pin, with the switch raised vertically and rotated horizontally one step, should be 0.010 inch minimum, and the contact pressure, measured at the point of contact on each spring, should be a minimum of 30 grams. The combined tension of the vertical off-normal springs should not be sufficient to prevent the complete restoration of the shaft to vertical normal from any position between the first level and vertical normal.

(4) Check the adjustment of the off-normal contact assemblies by making sure that the contacts make when a gage of 0.020-inch thickness is inserted between the clamp which holds the normal pin and the switch shaft.

b. CAM AND CAM CONTACT ASSEMBLIES (fig. 45).

(1) Check the position of the cam on the switch shaft. The actuating part should normally be set under the fourth tooth of the shaft rotary ratchet counting from the rear. Adjust by loosening the two collar clamping screws and alining the cam. Tighten the screws securely when the adjustment is completed.

(2) Advance the switch shaft by hand on one of the bank levels to the tenth horizontal position. See that there is clearance of not more than one-sixty-fourth inch between the engaging surface of the cam and the contact bumper. Advance the shaft to the eleventh position. If the cam is properly alined on the switch shaft, the contact assembly should now be in its operated position. The cam collar should clear the insulator of the engaging contact by not more than five-sixty-fourth inch. The insulator on the cam engaging surface should clear the rotary ratchet by not more than one-sixteenth inch with the switch shaft in the normal position.

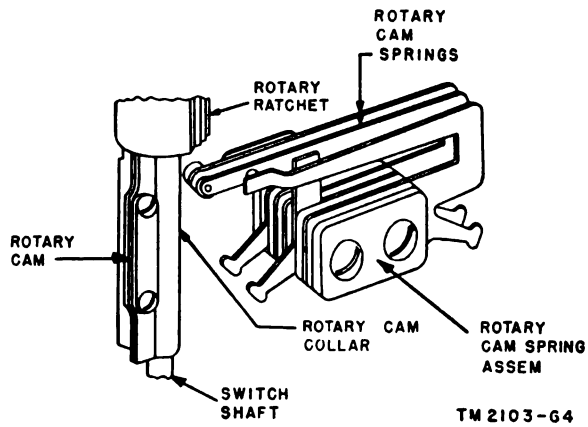


Figure 45. Cam and cam contact spring assembly.

(3) The minimum allowable contact separation for make or break contacts is 0.006 inch. If there are two or more adjacent break combinations, the minimum clearance between each lever spring and the insulator of the lever spring in the adjacent break combination is 0.002 inch.

(4) Make or break springs must have a perceptible follow when making or breaking contact.

(5) Normally closed contact springs of make-before-break combinations must have a minimum tension of 45 grams, measured at the end of the longer contact spring.

(6) Lever contact springs must have a minimum tension of 20 grams against their back contact or against the adjacent lever contact spring, in the direction of the cam, measured midway between the insulator and the contact.

(7) Make contact-spring combinations must have a contact pressure of 20 grams when closed.

c. Rotary Interrupter Contact Assemblies (fig. 29).

(1) The rotary interrupter springs should break contact, with the rotary magnets electrically operated, as follows: on switches operating self-interrupted, the break must be a minimum of 0.007 inch and a maximum of 0.015 inch; when used with interrupter relays, the break must be a minimum of 0.003 inch, and a maximum of 0.008 inch.

(2) The contact pressure must be a minimum of 150 grams, and a maximum of 300 grams measured at the end of the spring with the armature in its nonoperated position.

51. 25-point Rotary Stepping Switches (fig. 46)

a. Brush Springs. The brush springs (part of the switch bank assembly) should rest against the inner hub of the wiper assembly with sufficient tension to assure good electrical contact as the wiper assembly rotates. Adjustment of the brush springs normally is not required. If, however, adjustment is necessary—

(1) Remove the two bank adjusting screws (figs. 46 and 47). Remove the top part of the frame which supports the rotary mechanism. Lift the rotary mechanism out carefully. Avoid damaging the brush springs and wiper assembly.

(2) Tension and curve the brush springs so that the ends of the two springs of each pair are separated one-fourth inch, with all pressure removed. When replaced in the wiper assembly, the springs of each pair should close to within one-fourth inch of their ends.

b. Switch Bank.

(1) The edge of the broad wiper tip next to the ratchet gear should be in alinement with the front edge of contact numbers 1 and 25. The edge of the other wiper tips should rest approximately in the center of the switch bank contacts.

(2) The broad wiper tip should clear adjacent contacts by one sixty-fourth inch with the wiper assembly at rest.

(3) Adjust the rotary pawl stop and the switch-bank adjusting screws to meet the requirements outlined in (1) and (2) above. Set the wiper tips on the twenty-fifth contact by moving the pawl stop. Set the wiper tips on the first contact by turning the switch-bank adjusting bushing at the armature end of the switch. Check the setting of the tips on the eleventh contact.

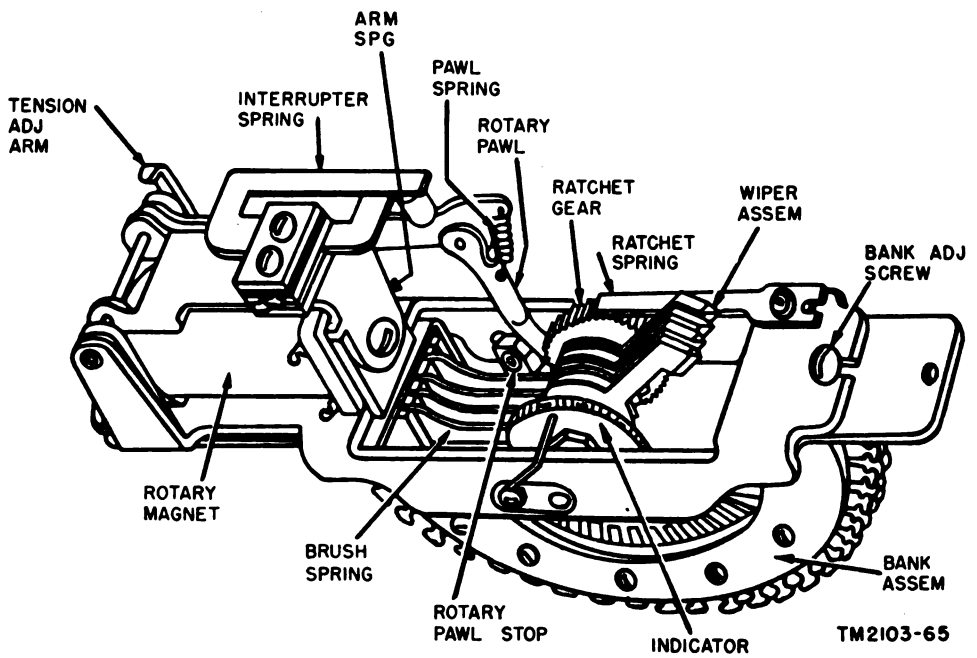


Figure 46. Typical 25-point rotary stepping switch.

c. Armature Stop.

(1) The pawl stop positions the wipers accurately on the bank contacts. It is not intended to stop the full force of the armature driving stroke. Such a condition would result in short life for both the pawl and the ratchet gear. An armature backstop (fig. 47) is provided to arrest the driving blow of the armature just before the pawl engages its stop.

(2) Set the armature backstop to relieve the pressure of the pawl against the pawl stop. Loosen the backstop mounting screw and tap the end of the backstop until it rests against the armature while in its nonoperated position. Tighten the mounting screw slightly and tap the armature backstop against the armature until there is barely perceptible play between the pawl and pawl stop. Tighten the mounting screw securely.

(3) The armature backstop should allow play in the wiper assembly when the armature is against the backstop and engaging any ratchet tooth. This play should be noted on at least one tooth.

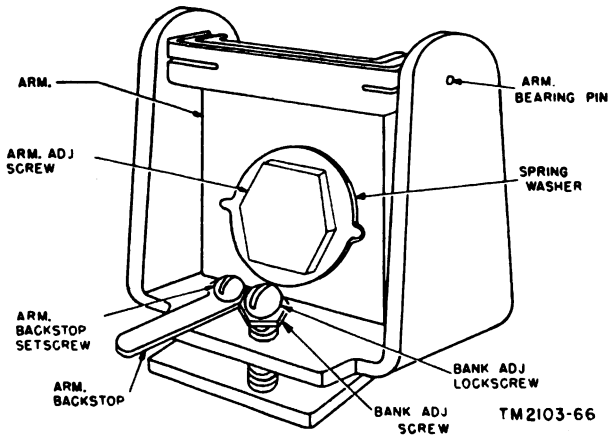


Figure 47. Rotary armature adjustment points.

d. Ratchet Spring. With the armature against the armature backstop the tip of the ratchet spring should clear the radial surface of each ratchet tooth by not more than 0.004 inch.

e. Rotary Armature (fig. 47).

(1) The armature must not bind on its bearing nor on the bearing pin locking spring. The pawl must not bind on its bearing nor on the switch frame.

(2) The pawl spring should hold the tip of the pawl firmly against the ratchet teeth when the armature is operated.

(3) The contact spring bumper must fit tightly on the armature and be in line with the associated interrupter springs.

(4) The tension of the spring washer should be sufficient to hold the armature stroke adjusting screw securely in place (fig. 47). Adjust the armature stroke so that the pawl just drops in on the next ratchet tooth, without binding on the tip of the tooth, with 0.002-inch clearance between the adjusting screw and the magnet core. The pawl should not drop in without binding when there is 0.005-inch clearance between the screw and the magnet core. Insert the proper thickness gage between the armature and the magnet core. Operate the rotary armature by hand, and move the pawl by hand to check its relationship to the ratchet teeth.

f. Magnet Interrupter Contacts.

(1) When a gaging value of 0.003 inch is specified for a make or break of the interrupter contacts on the manufacturer's circuit requirement, or switch adjustment sheet, the interrupter contacts must make or break when there is a 0.002-inch gage placed between the stroke adjusting screw and the magnet core. The contacts must not make or break with a 0.005-inch gage placed between the stroke adjusting screw and the core when the magnet is electrically operated.

(2) When the gaging value specified is 0.004 inch for a make or break of the interrupter contacts, the contacts must make or break when a gage 0.002 inch less than the specified value is placed between the stroke adjusting screw and the magnet core. The contacts must not make or break when a gage 0.002 inch greater than the specified value is placed between the stroke adjusting screw and the core when the magnet is electrically operated.

(3) The tension of the interrupter contact spring must be between 250 and 400 grams, measured at the point where the bumper on the armature arm strikes the contact spring.

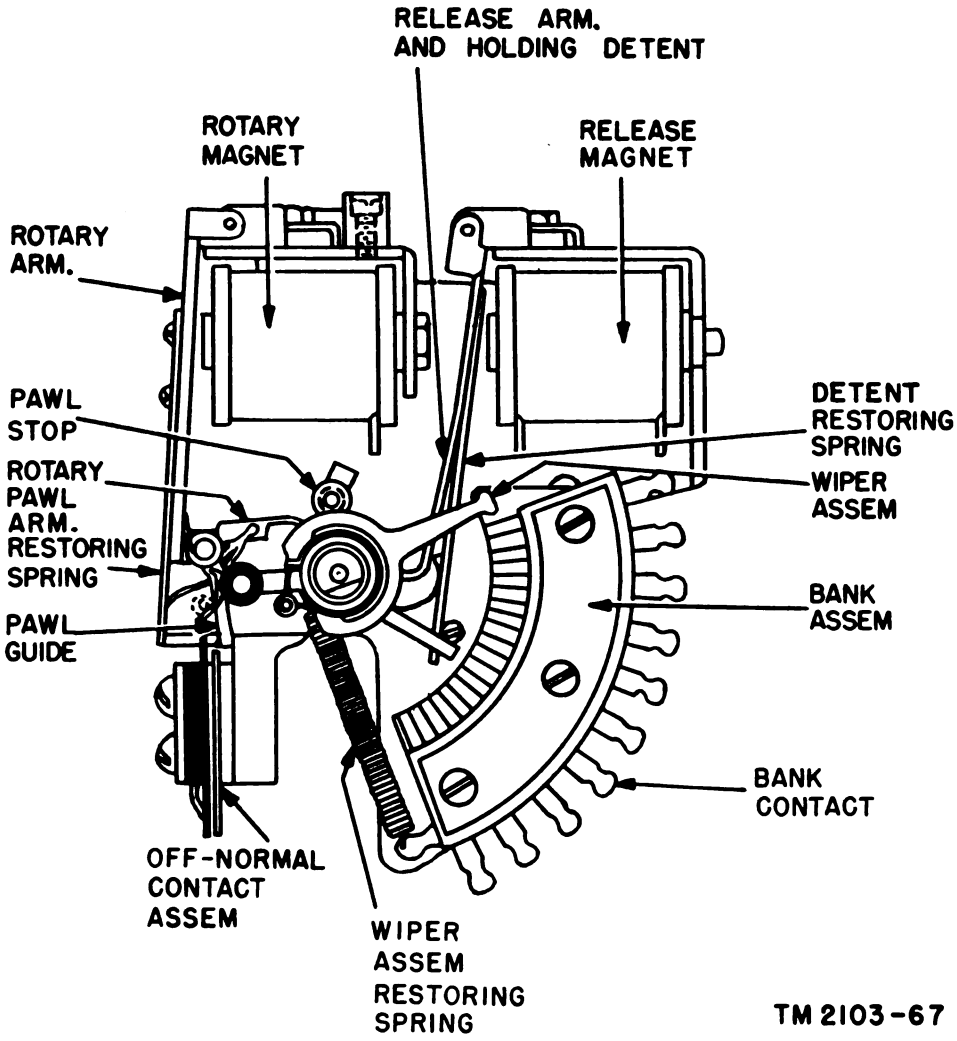


Figure 48. Minor switch.

g. WIPER ASSEMBLY.

(1) The wiper assembly must turn freely on its bearings. The backs of all wipers should be slightly flared. The wipers must be alined to fit over the ends of the brush springs without excessive movement to one side or the other. The wiper springs on the first level must clear the pawl and pawl stop by a minimum of one sixty-fourth inch during rotation.

(2) Each spring of a wiper having a broad flat tip for contact surface should be tensioned to follow approximately three thirty-second inch measured at the tip when its opposing spring is deflected.

(3) The tension of each wiper spring having a knife edge contact should cause a follow of approximately one-sixteenth inch measured at the tip, when its opposing spring is deflected.

(4) The indicator should be alined with the number or line on the indicating wheel corresponding to the bank contact on which the wiper tips are resting.

52. Minor Switches (fig. 48)

a. WIPER ASSEMBLY.

(1) The wiper assembly nut must be tight and the upper and lower spring of each pair of wipers must not be out of alinement (vertically) more than one-sixty-fourth inch.

(2) The tips of each pair of wiper springs should be separated approximately 0.015 inch when the wiper is off the bank. Check tension of wiper springs by observing that

each wiper spring has a follow of approximately one-sixteenth inch (measured at the tip) when its opposing spring is deflected. Each wiper spring must exert approximately equal tension on the bank contacts.

(3) The wiper assembly must not bind on its axis, nor have more than 0.005 inch vertical play. The roller of the off-normal arm must turn freely on its axis. The normal stop arm must make contact with the normal stop pin for at least one-sixty-fourth inch, and should not touch the wiper assembly restoring spring as the wipers operate or restore.

(4) The wiper assembly restoring spring must have enough tension to restore the shaft to normal from the second bank contact when the shaft is retarded by hand.

(5) When the oil slot in the shaft does not extend to the end of the shaft, adjust the wiper assembly collar until its oil hole is in approximate alinement with the oil slot in the shaft.

b. BANK ASSEMBLY.

(1) With the wiper assembly at normal, the wiper tips should rest at a distance from the first bank contact, equal to one rotary step of the wipers. Adjust the contact bank assembly, if necessary.

(2) The bank assembly must be set so that the tips of the wipers pass over the approximate center of the visible length of each bank contact, and stop on the center of each bank contact, with respect to its width.

c. RELEASE ARMATURE.

(1) The release armature when operated must be approximately parallel to the end of the heelpiece, and must not bind on its bearings or on the heelpiece but have perceptible side play. The armature, when electrically operated, must clear the heelpiece with a gap of 0.004 inch maximum.

(2) The release armature stroke, measured between the armature and coil core, should be 0.020 inch (plus or minus 0.002 inch) unless otherwise specified on the associated circuit requirement or relay adjustment sheet.

(3) The engaging surface and edge of the detent should be alined with the ratchet teeth, and adjusted to hold the wiper tips approximately on the centers of the bank contacts.

(4) The release armature spring tension should be as specified on the manufacturer's relay adjustment sheet for the associated circuit.

d. ROTARY ARMATURE.

(1) The inner surface of the rotary armature must be approximately parallel to the end of the heelpiece. The armature, when electrically operated, must clear the heelpiece with a gap of 0.004 inch maximum. The armature must have perceptible side play and not bind on its bearings or on the heelpiece.

(2) The rotary armature backstop should allow an armature stroke (measured between the armature and coil core) of 0.030 inch (plus or minus 0.002 inch) unless otherwise specified on the associated relay adjustment sheet. With the above adjustment the rotary pawl will clear the ratchet teeth with the armature in its normal position.

(3) Set the depth of the rotary armature stroke so that the detent drops in on each ratchet tooth with a maximum clearance of 0.006 inch between the detent and tooth when the armature is electrically operated.

(4) The rotary armature spring must clear the end of the armature at all times and be set with its lower edge approximately parallel to the main switch frame. The surface of the frame should be smooth at the point of contact with the rotary armature spring, so that the spring moves freely. If it is necessary to replace the rotary armature spring, use the original mounting screws or use screws of the same length that will not strike the rotary magnet when the armature operates.

(5) The rotary armature spring tension should be as specified on the manufacturer's relay adjustment sheet for the associated circuit.

e. PAWL.

(1) Aline the pawl exactly with the ratchet teeth. It must operate freely on its bearing, and not bind on the switch frame.

(2) The pawl spring is adjusted at the factory to hold the pawl guide arm against the switch frame with a minimum pressure of 50 grams or a maximum pressure of 100 grams.

(3) Make sure that the pawl strikes the tenth tooth of the ratchet, counting clockwise from the restoring spring hook, in the same

relative position in which it strikes the other teeth. If it is necessary to bend the normal finger, recheck the bank setting (*b* (1) above).

(4) The rotary armature must strike against the magnet core before the pawl strikes the stop. With the rotary armature electrically operated, there should be perceptible rotary play in the wiper assembly.

f. Off-Normal Spring Assembly.

(1) With the wipers resting on the first bank contact, there should be perceptible clearance between the off-normal arm roller and the operating contact spring. The spring should strike in the center of the roller.

(2) Make or break contact assemblies have a minimum contact separation of 0.008 inch. The lever springs should have sufficient tension, with the wiper assembly off-normal, to insure good contact. The tension must not be great enough to prevent the release of the switch from the first step. Back contact springs must have perceptible follow.

(3) The off-normal arm roller must engage the curved tip of the first lever spring so as to restore the contact assembly properly when the wipers are released from either the first or last bank contact. The off-normal arm must not cause the operating lever contact spring to become unnecessarily bent or bowed, as it is engaged by the off-normal arm bushing.

53. Dial Adjustment

a. General. Although dials (fig. 49) are properly adjusted before shipment from the factory and operate for long periods of time without adjustment, minor adjustments may be required occasionally. Inspect the dial as indicated below.

b. Routine Inspection.

(1) Tighten all mounting screws. Check for loose or worn parts. Replace defective, marred, or mutilated parts. See that the dial finger plate (fig. 49) does not bind on the finger stop and that the number plate is clean and not damaged.

(2) Spring contacts must not be out of alinement with respect to each other more than one-third of their diameter measured at the base of the contact point. Gage by eye.

(3) Make sure that the mechanism is free from grease, dirt, or any other foreign matter which is likely to impair its operation.

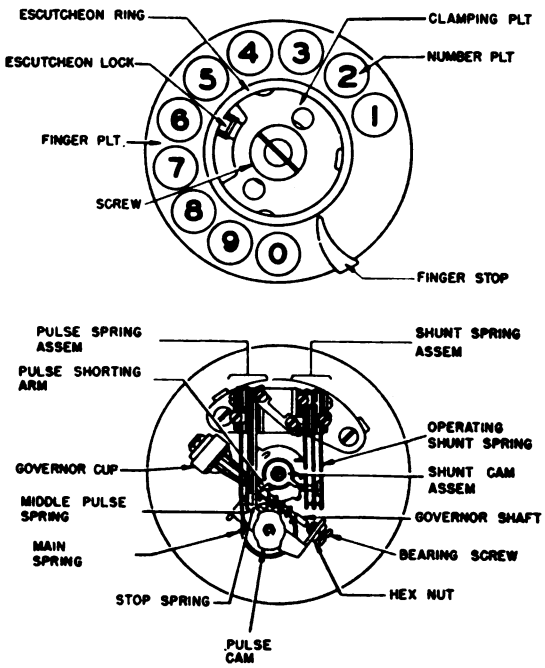


Figure 49. Dial assembly.

c. Removing Dial Escutcheon Card Assembly.

(1) Insert escutcheon tool (Auto Elec H–26917) under the escutcheon ring at the digit 5 finger hole (fig. 50). Press the tool down against the locking lever underneath the card. Move the tool counterclockwise to the digit 6 finger hole (fig. 51). This unlocks the card assembly. With the tip of the tool, lift the escutcheon ring at the digit 6 finger hole and remove the card assembly.

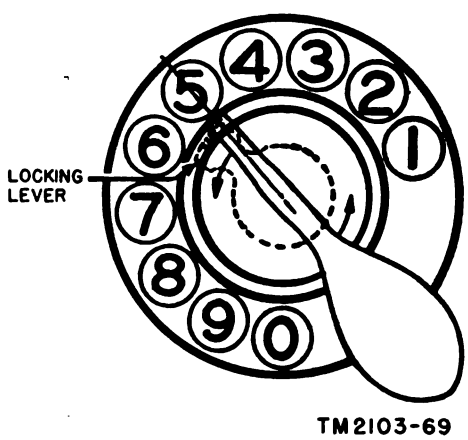


Figure 50. Unlocking escutcheon ring.

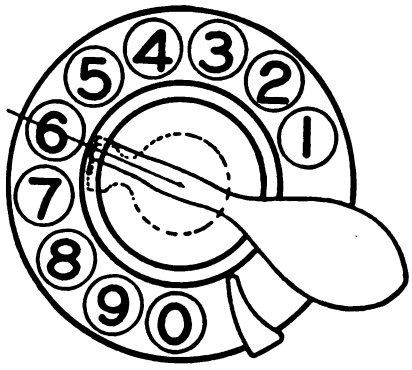


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Figure 51. Escutcheon ring unlocked.

(2) The escutcheon ring, transparent cover, number card, and number-card clamping plate comprise the card assembly. Release the components by turning the assembly face down and slightly rotating the notched clamping plate in a counterclockwise direction. Note the relative position of the parts as they are removed. They must be assembled in the reverse order of their removal.

d. Ratchet Pawl Adjustment.

(1) Check the clearance between the shaft stop arm and its associated stop. With the dial at normal, the ratchet pawl should rest against its stop so as to give a minimum clearance of 0.008 inch, or a maximum clearance of 0.030 inch between the shaft stop arm and its associated stop.

(2) If adjustment is necessary, remove the finger plate and the number plate. Bend the pawl stop to obtain the specified clearance.

e. Main Spring Adjustment (figs. 49 and 52).

(1) The main or restoring spring should have a tension of one to one and one-third turns with the dial in the normal position. Check by removing the main spring from the main shaft, counting the turns made by the spring until all tension is released. Remove the spring by holding dial face down in the left hand so that the dial finger plate cannot revolve. Grasp the shunt cam with the right hand and turn it slightly counterclockwise. This will release the cam and the spring which can be slipped from the shaft.

(2) When remounting the spring, make sure it has proper tension. Increase the tension of the main spring by engaging the lower end of the spring in the hook back of the previously used hook. Decrease the tension of the main spring by engaging the spring in the hook in front of the previously used

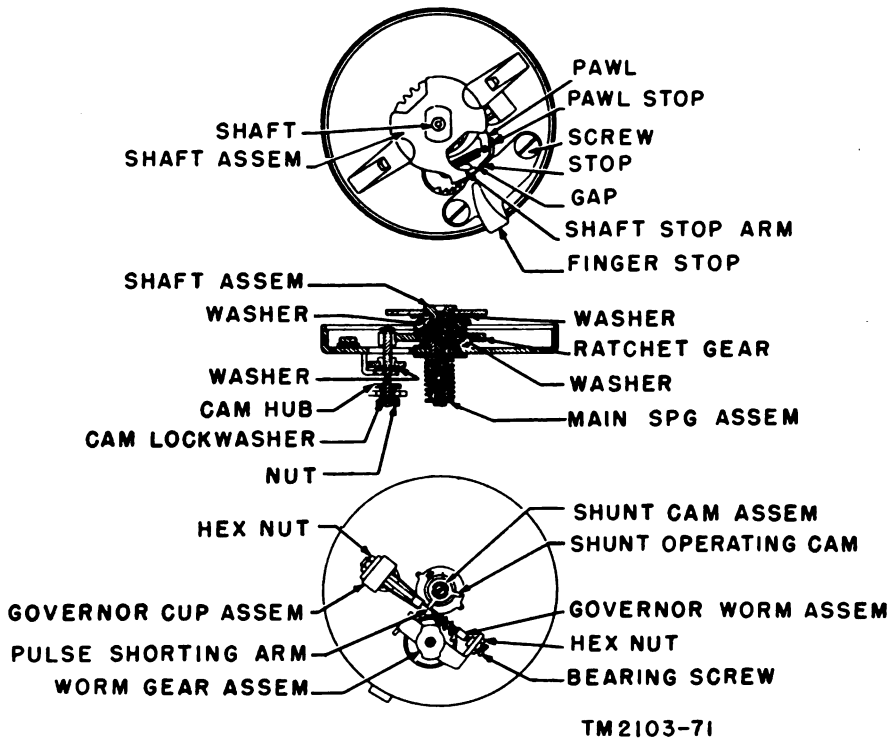

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Figure 52. Dial subassembly.

hook. Hold the dial in the left hand, the shunt cam in the right, then rotate the shunt cam the correct number of turns in a counterclockwise direction. Push down until the spring end slides in the key slot in the shaft.

f. Pulse Spring Adjustment.

(1) With the dial at normal, the pulse spring contacts should be closed.

(2) When not engaged by the pulse shorting arm, the middle pulse spring should rest firmly against the heavy stop spring.

(3) With the finger plate off normal and the tip of the main pulse spring opposite a low side of the pulse cam, the tension of the spring should be a minimum of 25 grams or a maximum of 50 grams. Apply the tension gage to the crimp in the spring.

(4) The heavy stop spring must hold the middle and main pulse springs so that, with the finger plate off normal and the tip of the main pulse spring opposite a low side of the pulse cam (B of fig. 53), the separation between the tip of the spring and the cam should be approximately the same as the separation between the contacts when the tip of the main pulse spring is resting on the high side of the pulse cam (C of fig. 53). Adjust the stop spring with smooth-jaw pliers.

(5) The pulse shorting arm should cause the main pulse spring to clear the pulse cam by a minimum of 0.015 inch or a maximum of 0.030 inch during the short-circuited pulse (last pulse). Adjust by bending the

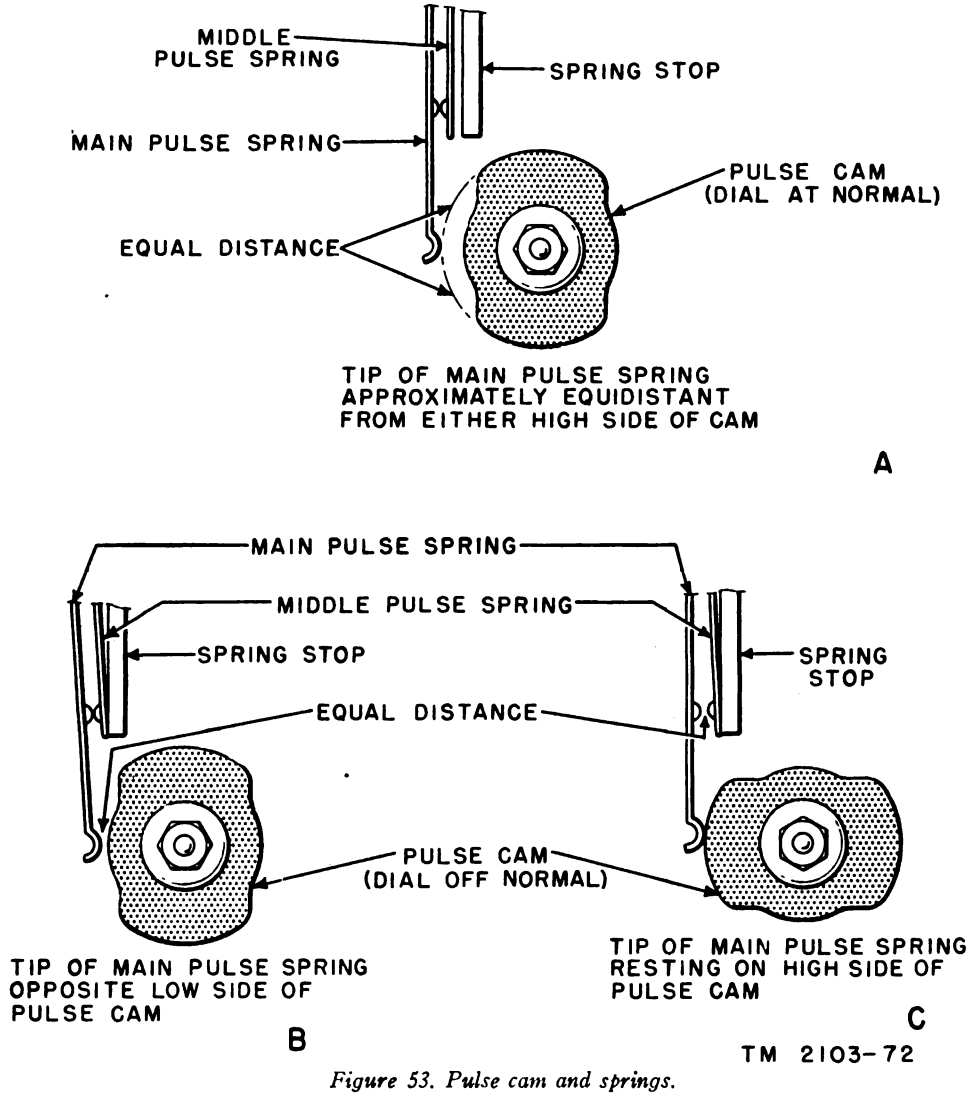

Figure 53. Pulse cam and springs.

shorting arm with smooth-jaw pliers. If this adjustment does not meet the requirement, replace the dial.

(6) The pulse shorting arm must not cause any pulse spring to move until after the last pulse is actually transmitted. Gage by eye.

g. SHUNT SPRING ADJUSTMENT (figs. 49 and 52).

(1) Tension the shunt spring contacts so that as the dial moves off normal each spring will make contact with its associated spring while traveling through a minimum distance of 0.015 inch. Adjust the springs to meet this requirement.

(2) When the dial is in the normal position, there must be a minimum separation of 0.015 inch or a maximum separation of 0.030 inch between the normally open contacts. Adjust the springs to meet the requirement.

(3) During the return of the dial to normal, the shunt cam must turn with the finger plate when the pulse cam rotates. If this requirement is not met, replace the dial.

h. GOVERNOR ADJUSTMENT (figs. 49 and 52).

(1) There should be perceptible end play in the governor shaft assembly, not exceeding one-sixty-fourth inch. To adjust, loosen the locknut, then tighten or loosen the adjustment screw as required. Tighten the locknut securely after the adjustment is completed.

(2) The dial must operate at a speed of not less than 8 pulses per second nor more than 12 pulses per second. The normal or desirable dial speed is 10 pulses per second. Adjust the governor assembly by bending the governor wings to increase or decrease the pressure between the governor weights and the governor cup to maintain the correct dial speed. Keep the governor wings formed as nearly alike as is possible.

i. PULSE CAM.

(1) The pulse cam must be set so that with the dial in the normal position, the tip of the main pulse spring is approximately equidistant from either high side of the cam (A of fig. 53).

(2) To adjust, hold the cam hub nut with an open end wrench and loosen the cam nut with the cam socket wrench. Position the cam as required. Tighten the cam nut securely after the adjustment is completed.

j. REPLACING DIAL ESCUTCHEON CARD ASSEMBLY.

(1) To reassemble the components of the dial escutcheon card assembly, first insert the transparent cover, then the dial card, and finally the dial card clamping plate in the dial escutcheon ring. Turn the clamping plate in a clockwise direction to engage the tongue and lock the assembly.

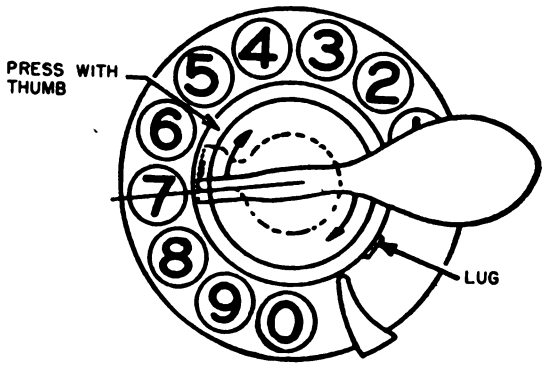

Figure 54. Locking escutcheon ring.

(2) Check the position of the locking lever on the finger plate, making sure that it points midway between digits 6 and 7. Insert the small lug on the escutcheon ring into the slot just above the finger stop. Press the assembly down into the finger plate. Hold the assembly in place and insert the dial escutcheon tool under the escutcheon ring adjacent to digit 7 (fig. 54). Press the tool down against the locking lever underneath the card and move in a clockwise direction to the digit 6 finger hole. This locks the card in place (fig. 55). Remove the tool.

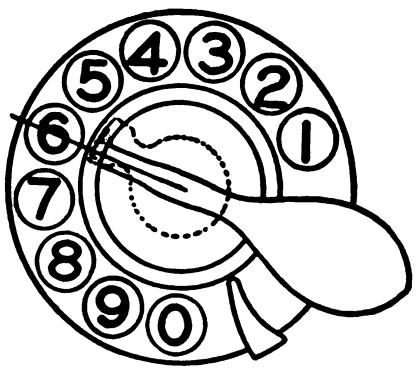

Figure 55. Escutcheon ring locked in place.

54. Lever Switches, Rotary-type and Push-type Switches, and Switchboard Jacks

All switch and jack contacts should be cleaned before making adjustments. Follow the contact cleaning procedures outlined in paragraph 55.

a. Lever Switches (Keys) (fig. 56).

(1) The lever springs should clear the switch frame when the switch is in the normal position by a minimum of 0.005 inch. Adjust by loosening the spring assembly screws and shifting the springs as required. Tighten the screws securely after adjustment is completed.

(2) The tips of the lever springs should engage the entire width of their respective rollers when the switch is operated in a direction to move the springs. Gage by eye. Adjust by loosening the spring assembly screws and shifting the springs.

(3) Take up the play in the lever switch in a direction away from a lever spring. There should be perceptible clearance between the tip of that spring and the associated rollers. Gage by eye. Adjust the lever spring as required with a pair of smooth-jaw pliers.

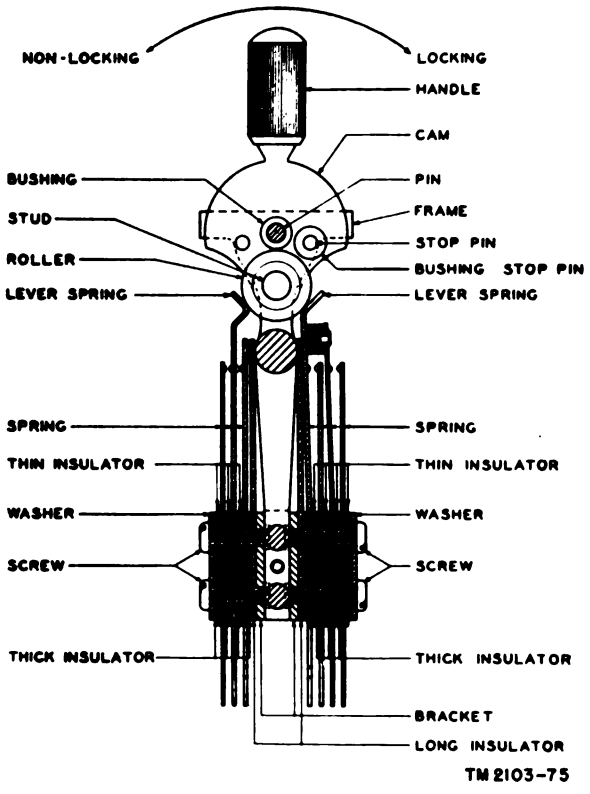

Figure 56. Lever switch.

(4) Lever springs associated with a back contact or an insulator should, with the switch in the normal position, rest against that contact or insulator with a minimum pressure of 300 grams. Adjust the tips of the lever springs as required.

(5) When a lever spring is not associated with a back contact or insulator, the minimum tension of the spring should be 20 grams, with the switch in the normal position.

(6) Contacts should line up so that the point of contact is not out of alinement with the centers of the contacts by more than one-fifth of their diameter. Gage by eye. To adjust the contacts, loosen the spring assembly screws and shift the springs to meet the requirement.

(7) The minimum separation between lever switch contact (unless otherwise specified) should be 0.010 inch when the contacts are open. Gage by eye.

(8) Make contacts of break-make spring combinations should have a minimum separation of 0.025 inch when the switch is in the normal position.

(9) Break contacts should have a maximum contact separation of 0.015 inch when the switch is in the operated position.

(10) The minimum follow of normally open contacts should be 0.010 inch (test) or 0.015 inch (readjust).

(11) The minimum follow of normally closed contacts should be 0.008 inch (test) or 0.010 inch (readjust).

b. Rotary-Type and Push-Type Switches (fig. 57).

(1) The turn button or plunger must not bind. Remove and clean the parts with carbon tetrachloride if required.

(2) The main springs of plunger-type switches must have enough tension to restore the plunger to its normal position from the fully operated position. The tension should be distributed equally between the main springs.

(3) Make-contact springs should have a minimum follow of 0.015 inch after making contact. Break-contact springs should have a minimum follow of 0.010 inch after breaking contact. Gage by eye.

(4) Contact springs must be alined. If misalined, loosen the spring assembly screws

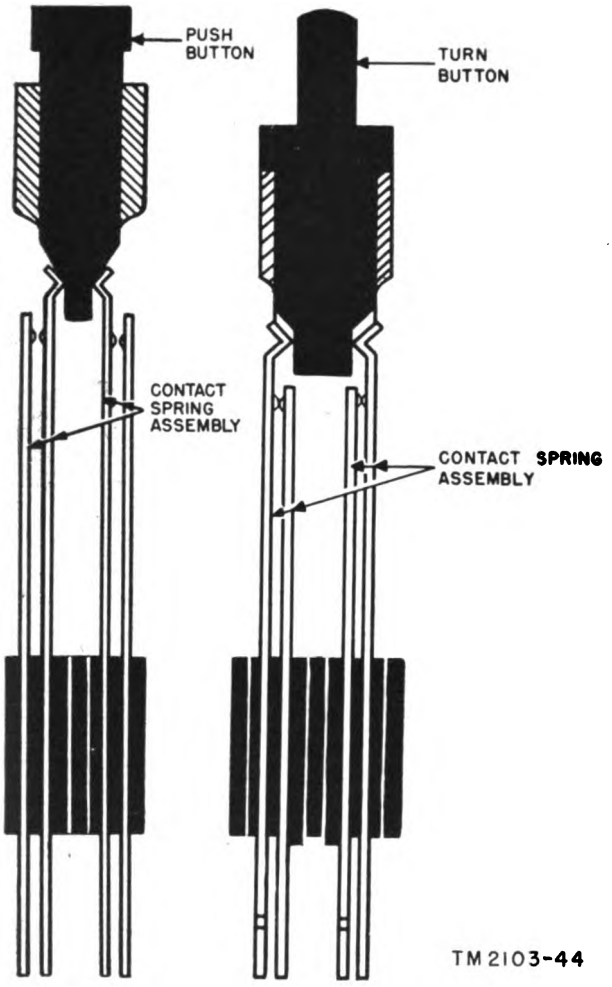

Figure 57. Rotary-type and push-type switches.

and shift the springs as required. If the springs are bent, bowed, or have excessive follow, straighten the springs or reduce the excessive follow as required with smooth-jaw pliers or a spring adjuster.

c. SWITCHBOARD JACKS (fig. 58). Switchboard jacks, either single- or strip-mounted, normally will give long service without cleaning or adjustment. If adjustment or cleaning is necessary, proceed as follows:

(1) Check the jack for wear and improper spring adjustment with the correct gages. If gages are not available, use a new switchboard plug. Inspect the sleeve and spring contacts for excessive wear. Measure the sleeve wear with a plug gage. Replace the jack if the sleeve or the contact springs (at the crimped portion) are worn more than one-half of their thickness.

(2) If adjustment of the ring or tip springs is required, make the adjustment from the front of the switchboard with a jack spring adjusting tool (WECo. No. 117 or equivalent). When increasing the tension of the springs with the adjusting tool, make sure that the spring is not bent far enough to cause a *butt* condition.

(3) Should adjustment from the front of the switchboard fail, remove the jack strip from the panel, at the rear of the switchboard, and turn the strip to gain access to the jack springs. Spring and contact tension adjustments can then be made with duck-bill pliers. Adjust for spring tension by placing the pliers on the springs just back of the crimp. Adjust for contact tension by placing the pliers on the spring just ahead of the insulators. Contact spring follow should be approximately 0.010-inch minimum. Replace the jack strip if the springs are damaged or excessively worn.

(4) Clean the crimps of the ring and tip springs by inserting a newly cleaned switchboard plug in the jack and rotating the plug against the springs. Inserting and withdrawing the plug two or three times while rotating the plug, will polish the crimps. Keep the plug clean by wiping with a lint-free cloth.

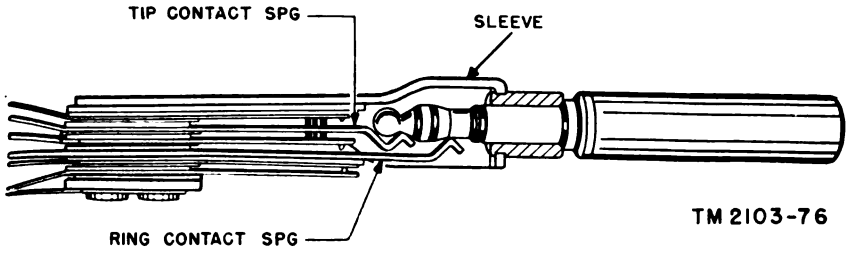

Figure 58. Telephone-type jack.

(5) Clean dirty jack sleeves with lint-free cloth and an orange stick. Use a strip of cloth approximately 5 inches long by 1½ inches wide. Fold the cloth to ¾-inch width and wrap spirally around the orange stick. Use three layers of cloth per inch. Secure the free end of the cloth between the thumb and the stick. Moisten the end of the cloth in solvent (SD) (table V) with about 15 drops of oil (PL-Special). Insert the moistened wrapped stick in the jack sleeve. Rub back and forth, contacting all sleeve surfaces. Replace the cloth when dirty. Avoid touching the jack springs, if possible.

55. Miscellaneous

a. TEST JACKS (fig. 21).

(1) The contact spring tips of the test jacks should be bent (when necessary) so that the test plug will readily enter the jack when the plug is held at approximately a 10-degree angle above the horizontal.

(2) Each jack spring should make contact with its corresponding plug terminal. Adjacent pairs of springs should have a minimum clearance of one-thirty-second inch.

b. BUSYING SWITCH (fig. 59)

(1) The cam contact spring of the busying switch *(busy key)* should contact the cam the full width of the cam surface. On make-before-break combinations, the break spring need not meet the follow requirement, but must have a minimum contact pressure of 50 grams. All break contacts, except the make-before-break combinations, should open before any make contacts close. Gage by eye.

(2) With the busying switch at normal and one side of the formed end of the cam spring resting against the cam slot, there should be a 0.005-inch minimum or a 0.020-inch maximum clearance between the other side of the formed end of the cam spring and the cam slot.

(3) When the first spring is a cam spring, the above clearance is not required but the tension of the cam spring against the cam should not exceed 120 grams, measured at the end of the spring.

Note. The springs may be bent to meet this adjustment.

(4) There must be a minimum 0.010-inch clearance between all springs and the flat side of the frame, and the last spring of the pile-up and the end of the frame. There should be perceptible clearance between the cam spring and the bumper or the second moving spring.

c. SHELF CONNECTORS (SHELF JACKS). Equipment mounting bases have a row of nickel-silver male contacts, forming a male connector, mounted on the rear of the base. These engage a similar row of contact springs, forming a female connector (fig. 60) (commonly referred to as a shelf jack), mounted on the shelf frame. Since all nonswitching circuits which enter or leave the equipment mounted on the base pass through these connectors, disconnecting any wires is eliminated when removing one of the units from the shelf frame.

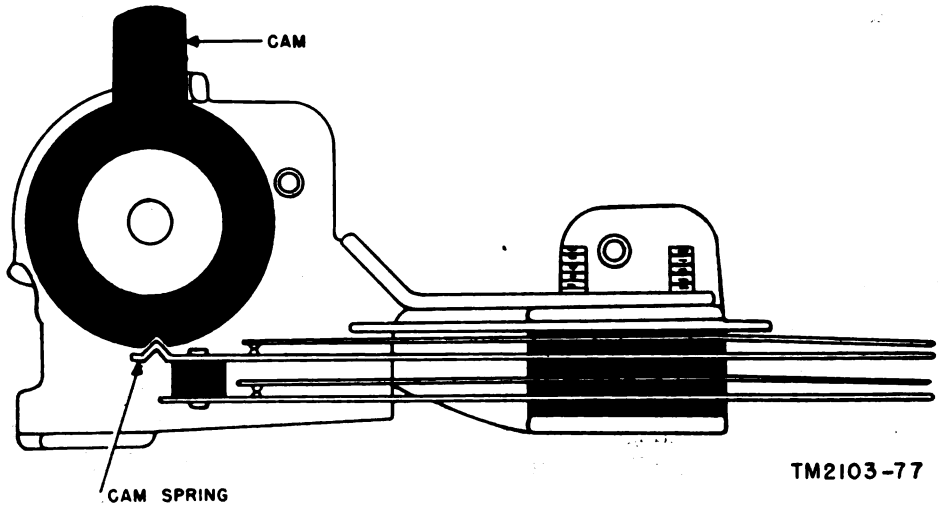

Figure 59. Busying switch.

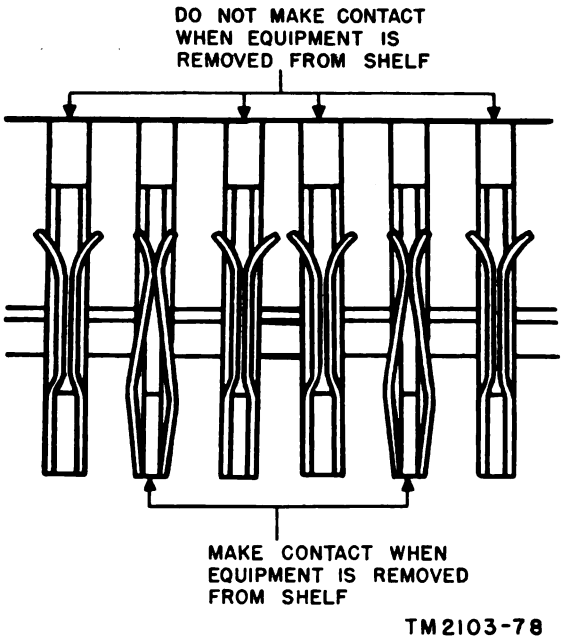

Figure 60. Shelf jack contacts.

(1) Adjustment will rarely be required for the shelf jack. When a pair of connector springs are required to make contact upon removal of the unit from the shelf, inspect and adjust the springs if necessary.

(2) When the unit is removed from the shelf, the clearance between each pair of shelf jack contact springs not required to make contact should be a minimum of 0.020 inch or a maximum of 0.050 inch, gaged at the closest point between the contacting surfaces.

(3) The springs of a pair of contacts should be approximately parallel. The forming of the tips or terminals must not be altered to meet any requirements during adjustment.

(4) There should be perceptible clearance between adjacent springs not in the same pair of contacts when a unit connector is properly inserted in the shelf jack.

(5) When a pair of contact springs are required to make contact with the unit removed from the shelf, the make contact springs shall be tensioned against each other so that when the pressure of one spring of the pair is removed, its mate will follow approximately three-sixty-fourths inch. Gage by eye.

d. Equipment Bases and Covers.

(1) The angles of the upper mounting slots and the extreme lower angles of the rear of the switch base must be bent out to hold the base approximately centered in the shelf mounting space. Gage by eye.

(2) Each switch front cover must rest on the top surface of the mounting plate. The cover should also fit snugly on the sides of the mounting plate. Covers must not bind enough to cause difficulty when being mounted or removed.

Note. When a minor switch is included in the two-motion stepping switch, its tenth bank contact terminals must be spaced so that they will not make contact with the switch front cover.

(3) The back cover of the switch should be securely held with its lower edge under the edge of the clamping spring, and the top edge secured by the retaining screw. When all apparatus is mounted on the mounting plate, the back cover must not make contact with any of their terminals.

Section II. RELAY CLEANING, TESTING, AND ADJUSTING

56. Definitions and Numbering

a. General. Relays used in step-by-step dial central office equipment do not require frequent adjustment. However, heavy use over a long period of time, contact wear, loss of spring tension or other factors may make readjustment of relays necessary to restore them to maximum operating efficiency. Adjustment consists mainly of bending contact springs and/or armature levers by means of special tools (par. 5). Never adjust a relay unless it is certain that the relay does not meet its test requirements.

(1) Refer to paragraph 5 for tools and gages used to check and adjust relays.

(2) Refer to paragraph 6 for other materials required for relay maintenance. See TM 11–2111 for detailed information. Refer to SIG 7, Organizational Spare Parts, and SIG 8, Higher Echelon Spare Parts, for availability and source of supply of replacement parts.

(3) Refer to the relay adjustment sheets (par. 58), issued by the manufacturer, for each circuit to obtain the operating requirements for each relay. These sheets specify mechanical requirements (spring gaging) and electrical requirements (current flow). Determine if a relay needs adjustment by testing it against these specified values.

(4) Use the current-flow test set (Auto Elec H–64645–1) to check the electrical operating characteristics of each relay (pars. 58 and 59). Figures 65, 66 and 67 show how to connect the current-flow test set for checking relays in various circuits. Refer to TM 11–2112 for complete operating instructions for the current-flow test set.

b. Electrical Definitions.

(1) *Operate.* When current is connected to the relay winding, the armature moves sufficiently to cause all normally closed contacts to break and all normally open contacts to make, reliably.

(2) *Nonoperate.* When current is connected to the relay winding, the armature does not move sufficiently to cause any normally open contacts to make, or reduce the pressure on normally closed contacts to cause an unreliable connection.

(3) *Hold.* After the relay has operated and the current is either reduced abruptly or interrupted momentarily, the armature does not move sufficiently to cause an unreliable connection between any contacts that have been closed, or close any contacts that have been open.

(4) *Release.* The armature moves from the core sufficiently to break contacts that have been closed and make, reliably, contacts that have been open.

(5) *Soak.* The application of a comparatively heavy or *soak* current immediately before the operate, hold, or release values are applied.

(6) *Energized.* Sufficient current to operate a relay is connected to its winding but the armature is prevented from assuming its operated position by the insertion of a gage between the armature and the core.

c. Mechanical Definitions.

(1) *Contact make.* Make contacts must make before the armature has reached its fully operated or restored position.

(2) *Heelpiece air gap.* Space between the end of the heelpiece and the inner surface of the armature when the relay is electrically operated (fig. 78).

(3) *Residual air gap.* Distance between the face of the relay core and the inner surface of the armature with the relay electrically operated and the residual screw touching the core (fig. 78).

(4) *Spring gaging.* Measuring the position of the armature with respect to the core when the contacts make or break. The measurement is made with a thickness gage of specified value, inserted between armature and core.

(5) *Contact assembly (or spring assembly).* Entire set of contact springs of a relay.

(6) *Contact pile-up (or spring pile-up).* Contact springs assembled in one bank or stack and operated by one lever of the relay armature.

(7) *Armature travel or stroke.* Gap between the core and the armature residual screw, or the nearest point on the armature itself when no residual screw is used, with the relay in its normal or unoperated position.

d. Relay Contact Numbering and Winding Locations.

(1) Figure 61 shows how contacts and springs are numbered on horizontal-type relays for step-by-step equipment. Contacts and springs in each pile-up in an assembly are numbered consecutively from one upward, starting with the spring nearest the heelpiece. If a relay has four springs mounted in a single pile-up, contact 1 is on the spring closest to the heelpiece and contact 4 is on the spring farthest from the heelpiece. If a relay has springs mounted in two pile-ups the upper pile-up (looking at the relay mounted in its operating position) is designated TOP and the lower pile-up is designated BOTTOM. Contacts and springs in each pile-up are numbered consecutively from 1 upward, as before, with a suffix T or B to indicate whether the contacts and springs are in the top or the bottom pile-up. Testing instructions on the manufacturer's relay adjustment sheets may vary, reading either SPG 8T of RLY P–3 or UPPER SPG 8 OF RLY P–3. In both cases, the eighth contact (or spring) in the

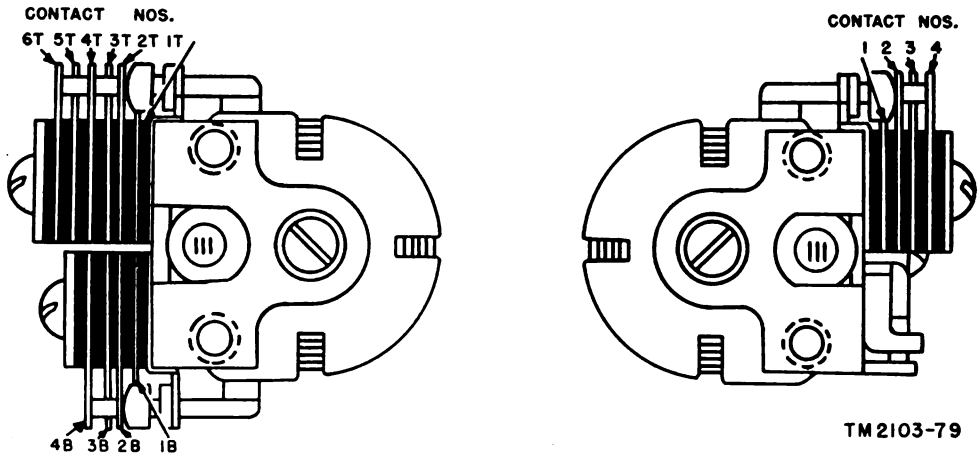

Figure 61. Contact numbering.

top contact pile-up of relay P–3 is meant, counting always from the heelpiece. It does not matter which end of the relay is viewed, but it must be placed in its correct relative operating position. If the relay has been removed from its mounting, the top and bottom pile-ups can be correctly identified by making sure the letter stenciled on the armature is right side up. If the case of letters like H and N, the manufacturer stamps this letter on the top half of the armature.

(2) The inside winding on concentric-wound coils or armature-end winding on two-section coils, is designated the No. 1 winding (fig. 62). The outer winding on concentric-wound coils or the heel-end winding on two-section coils, is designated the No. 2 winding. Note that the location of the terminals for the No. 1 winding and No. 2 winding on two-section coils is the reverse of the location of the terminals for the respective windings on concentric-wound coils (fig. 62). Also note the symbol designating the start or inside end of the coil winding. This symbol does not appear on the relay, but is marked for each relay on the circuit diagram of the equipment. Figure 62 shows the coils as mounted on the left side of a switch as viewed from the rear. When the relay is mounted on the right side of a switch, the location of the terminal connected to the inner end of the winding is the reverse of that shown; that is, for a single-wound coil the inner winding connects to the lower terminal.

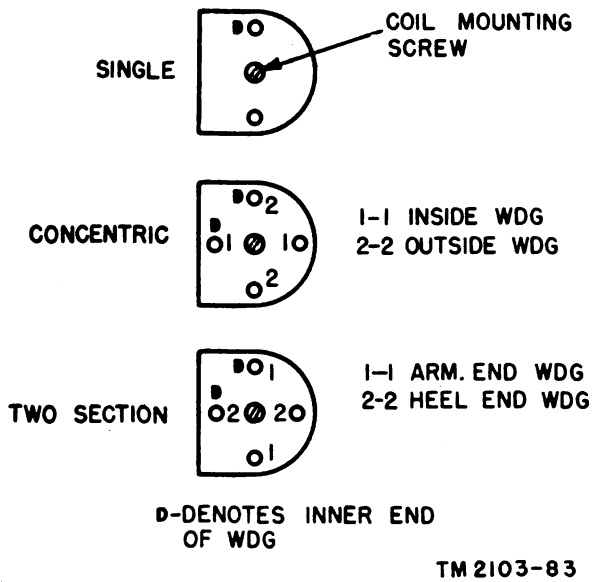

Figure 62. Relay winding location and numbering.

57. Relay and Relay Contact Cleaning

a. GENERAL.

(1) Failure of a circuit may be caused by dirt, corrosion, or lint on the contacts or other parts of a relay. Covers are provided on the equipment to reduce the entrance and accumulation of foreign materials on the working parts of relays. Keep the covers in place except when necessary to remove them in order to test or adjust the equipment. When relays are cleaned, wipe the inside of the cover with a lint-free cloth before replacing it.

(2) When cleaning relay parts, such as armatures and cores, make sure that the parts that touch are clean. On relays equipped with stop pins or residual screws, it will not be necessary to clean all of the core. Only the stop pin or residual screw will contact the core.

(3) Clean the armatures and cores by inserting a clean piece of bond paper between the armature and the core. Press the armature toward the core to apply a slight pressure between the paper and the part being cleaned. Then withdraw the paper. Repeat this operation several times, using a clean spot on the paper, until dirt is no longer deposited on the paper.

b. Contact Wear.

(1) Pitted or built-up contacts on relays and other apparatus do not prove that the contacts are useless. Do not replace relays or other equipment because of contact erosion unless contact is almost being made on the base metal to which the contact is welded. In the case of twin contacts, one contact of each mating pair may be worn nearly to the base metal before the apparatus requires replacement. When necessary, recondition contacts which are not excessively worn by removing build-ups and cleaning pits. Figure 63 shows progressive wear of dome contacts: (A) a new dome contact; (B) a pitted contact which can be reconditioned by cleaning; (C) a pitted contact which requires replacement of the relay or spring contact assembly.

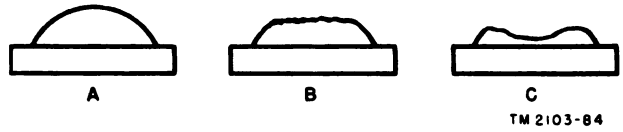

Figure 63. Progressive wear of relay contacts.

(2) Build-ups and pits on relay contacts result from the action of electric current as the relay makes and breaks contact. Sharp-pointed or excessive build-ups may result in the mechanical locking of the contacts in the operated or closed position. Remove build-ups or replace the relay.

c. Cleaning Nonpitted Contacts (fig. 64).

(1) Contacts that fail in service may normally be cleaned with a contact burnisher (WECo 265C, or equivalent) to remove any foreign material. Clean the blade of the burnisher used on the contacts by wiping it with a clean, dry cloth. Clean before and after using. When burnishing normally open contacts of a relay, place the blade of the burnisher flat between the contacts and press them together with an orange stick. At the same time, move the blade back and forth. Rubbing the burnisher blade between the contacts two or three times is usually sufficient. When burnishing normally closed contacts, the tension of the springs themselves usually furnishes sufficient pressure against the burnisher blade. On springs with heavy tension, lift one of the springs away to insert the burnisher blade.

(2) When unable to clear contact troubles by burnishing only, clean and flush the con-

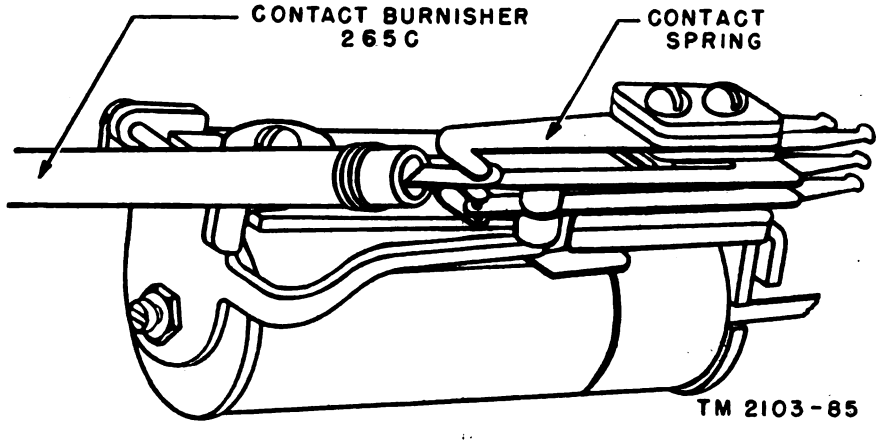

Figure 64. Cleaning relay contacts with contact burnisher.

tacts with carbon tetrachloride. Dip the flat end of a clean toothpick about one-half inch into the carbon tetrachloride. Deposit the liquid on the contacts (held slightly separated) without rubbing. Dip the flat end of another toothpick in the carbon tetrachloride and again deposit the liquid on the contacts without rubbing. This flushes away the dirt loosened by the first application. Keep the carbon tetrachloride from coming in contact with the relay spoolheads and insulators. Allow the liquid on the contacts to evaporate. When the contacts are *thoroughly dry*, burnish them as outlined above to insure that no deposit or residue from the solution, or any foreign material remains on the contacts. After burnishing, check that the requirements covering contact make and contact separation are still met. Repeated burnishing tends to increase the contact separation and to reduce the contact make. If necessary, adjust as specified on adjustment sheet covering the particular relay.

d. Cleaning Pitted Contacts.

(1) Burnish the contacts to be cleaned with the flat blade of the contact burnisher (WECo 265C). Do not attempt to remove a pit from a contact, but burnish only enough to clean the flat, contacting surface surrounding the pit.

(2) Burnish the pit with the wire burnisher (WECo 266C, part of burnisher 265C). Place the ball point of the burnisher in the pit. If the pit is small, rotate the barrel of the tool between the thumb and the finger, and at the same time apply a slight pressure on the tool against the contact. Repeat the operation with the burnisher held at various angles until the entire surface of the pit has been cleaned. After cleaning the pit, burnish again using the flat blade of the burnisher.

(3) When the burnishing is completed, check the contact make and separation requirements.

58. Relay Adjustments Sheets

The manufacturer supplies a relay adjustment sheet for each circuit in the dial central office that uses relays. These sheets are circuit requirement tables, listing the mechanical adjustment requirements and the electrical operating requirements. Mechanical requirements usually covered are the armature stroke, residual air gap, and contact spring gaging. References are made to standard adjustment sheets for other adjustments and requirements. Electrical requirements covered are the minimum current which should cause the relay armature to operate, and the maximum current that can flow in the relay coil without operating the armature. The relay adjustment sheet normally carries the same number as the circuit drawing with which it is associated, with prefix A added. In some cases, the number is the same as the manufacturer's part number for the assembly, except with prefix A. Figures 68, 69, 70, and 71 are examples of a typical relay adjustment sheet, using the manufacturer's nomenclature and abbreviations (Auto Elec AH–35868, which applies to circuit drawing No. H–35868). The columns on the adjustment sheets, reading from left to right, are explained in the following subparagraphs.

a. The first column, RELAYS, lists the circuit designation letters (A, B, etc.), the manufacturer's part number for each relay, the part number of the relay coil, the d-c resistance of each coil winding, and whether the relay is SO (slow-operating) or SR (slow-releasing). Omission of the SO or SR relay designation indicates that the relay is quick-acting. The circuit designation letters are those used in the circuit diagrams and the circuit explanation sheets, and stamped on the armatures of the relays themselves.

b. The second column, no heading, indicates the size of the residual air gap between the armature and the core, when the relay is electrically operated and the residual screw is touching the core.

c. The third column, SPRING GAGE, shows the contact spring arrangement for each relay. The decimal value beside each contact spring indicates the gap between the armature residual screw and the core as measured with a thickness gage, at the point in the armature travel when the contact mounted on that spring makes or breaks with its mating contact.

d. The fourth column, no heading, indicates the values for the first test and the second test for relays having two-step operation.

e. The fifth column, TEST FOR, indicates which values in the sixth and seventh columns are for (O) operate, (NO) nonoperate or (RLS) release tests.

f. The sixth column, RESISTANCE, indicates the values to be used with a resistance-type test set

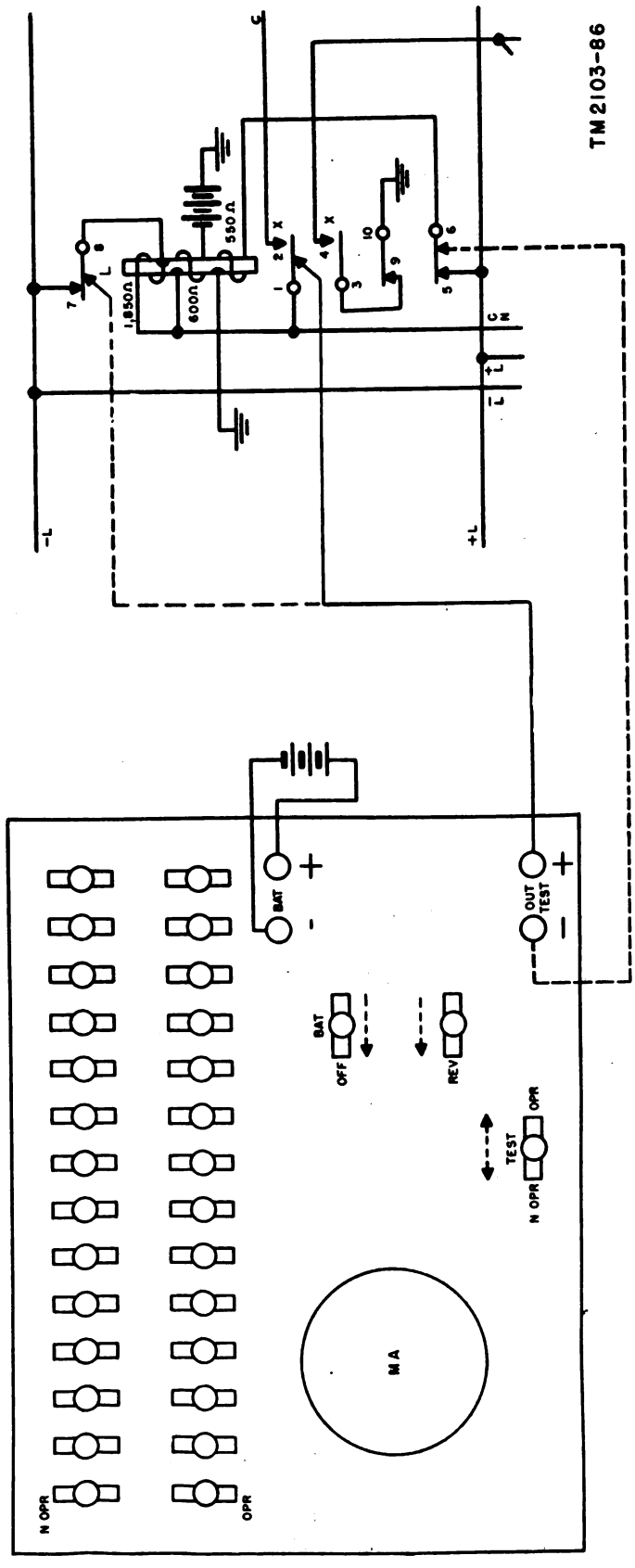

Figure 65. Testing relay having battery and ground connected to its winding.

and a specified voltage when checking relays by the resistance method. The resistance values given are also approximately correct for the amount of resistance to be placed in series with the coil winding for the current-flow tests.

g. The seventh column, CURRENT, specifies the current values, in amperes, for operate and nonoperate tests of relays with the current-flow test set. The resistance in the test set should be adjusted until these values of current are indicated on the meter. Under the subheading TEST, are listed the allowable limits when testing a relay; under the subheading READJ., are listed the values to use when readjusting a relay.

h. The eighth column, SEE NOTE, refers the reader to the block marked NOTES at the bottom of the sheet, which contains special test instructions.

i. The ninth column, TESTING INSTRUCTIONS, gives any special instructions necessary, and also indicates the point (or points) for connecting the current-flow test set to the relay under test.

(1) Figure 65 illustrates the connection of the test set to a relay with both battery and ground on the relay winding. The relay under test is a two-step relay with two testing operations required. The No. 1 test (indicated by dashed lines) places all of the relay windings in series. The No. 1 test (indicated by the solid line) checks only the relay winding that is energized on the final step. Arrows adjacent to the switches on the panel of the test set indicate the position of the switch levers for the relay test illustrated. Note that switch BAT (battery) is operated to the OFF position since this relay has battery connected. Also, the meter reverse switch is operated to correct the meter polarity.

(2) Note the following testing instructions of the manufacturer for the No. 1 test: "Connect test leads to springs 6 and 8 and switch BAT to OFF." Refer to figure 61 for the numbering arrangement of the relay springs. Figure 65 shows the connections of the current-flow test set (Auto Elec H–64645–1), and the circuit of the relay for the No. 1 test. The operate current values listed for the No. 1 test operate the relay armature just far enough to close contacts 2, 3, and 4.

(3) Note the following testing instructions of the manufacturer for the second test: "No. 2 test operates all springs. POS. to spring 1." This means that the + (positive) out-test cord is connected to No. 1 spring on the relay, and the other out-test cord is not connected. In this case, switch BAT on the current-flow test set (Auto Elec H–64645–1) is operated to the normal position.

(4) Figure 66 illustrates the test connections for relay F–3 on the typical relay adjustment sheet No. 2 (fig. 69), and figure 67 illustrates the connections for relay P–3 on typical relay adjustment sheet No. 3 (fig. 70). These are conditions similar to the No. 2 test in figure 65, where only one test lead is used.

(5) Refer to TM 11–2112 and to the specified relay adjustment sheet for operating information and relay testing information, respectively.

j. The title block at the lower right corner of the sheet indicates the circuit number and assembly drawing number of the equipment to which the sheet applies. General notes and explanation of terms are listed to the left of the title block. The block titled STANDARD ADJUSTMENTS lists the numbers of the manufacturer's standard adjustment instructions which are applicable to the equipment.

k. The NOTES block lists special and standard test instructions. When any note is specified for a particular relay, the test instructions in the referenced note apply, in addition to the instructions in the TESTING INSTRUCTIONS column. The meanings of abbreviations and terms used on the relay adjustment sheet are given in the EXPLANATION OF TERMS column.

l. Note that no current-flow values are given for relay B–3 in figure 68. This is a special vibrating-reed type relay, and the adjusting requirements only are listed. Reference is made to the manufacturer's standard adjustment sheet for the special mechanical requirements and adjustments of this type of relay. Refer to paragraph 62 for a description of adjustment procedures for vibrating-reed relays.

59. Relay Testing and Adjusting Procedure

a. Before adjusting relays, inspect and test them in accordance with the following routines. Adjust relays only when necessary. Paragraphs 60–63 give typical examples of adjustment requirements and procedures contained in the manufacturer's standard relay adjustment sheets.

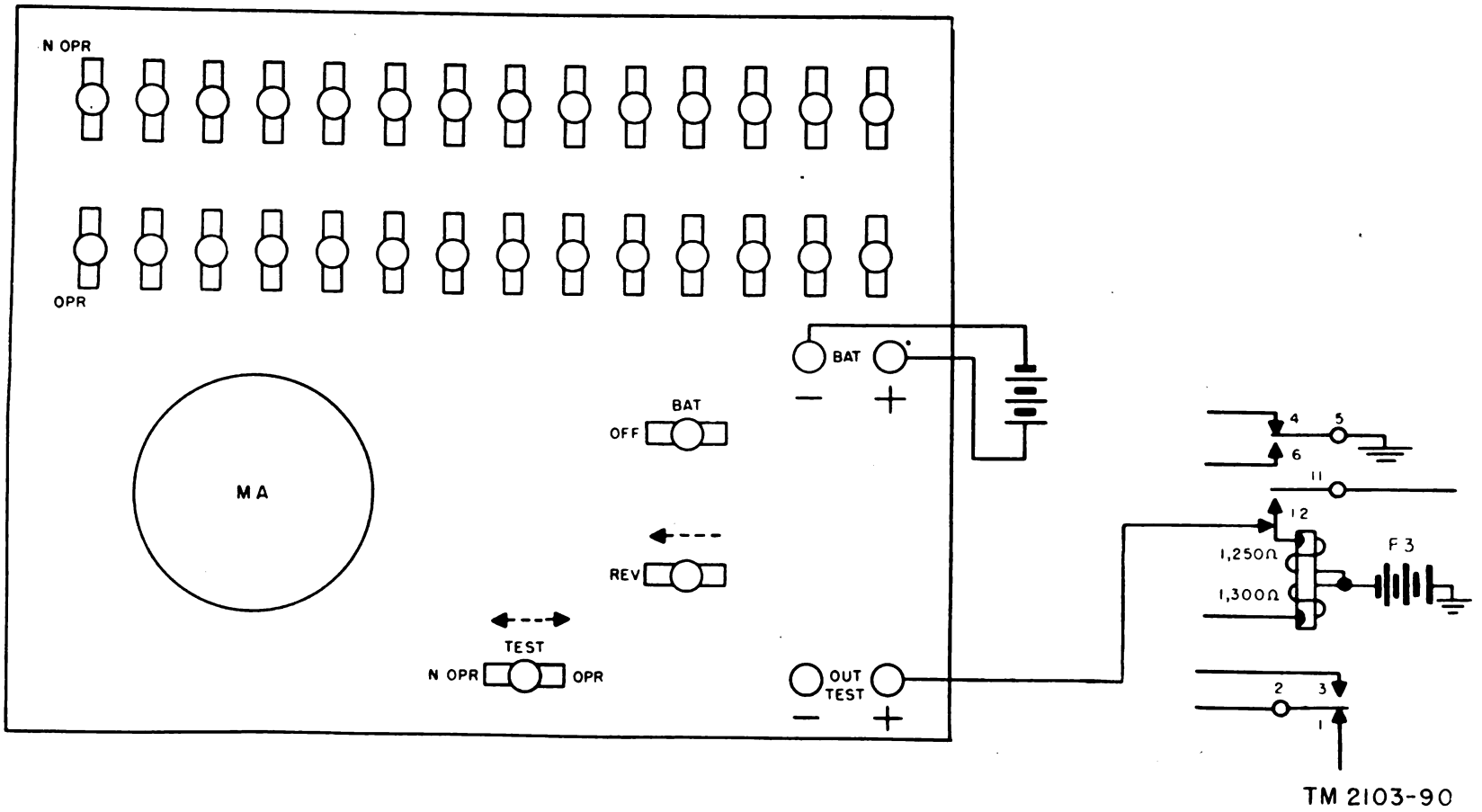

Figure 66. Testing relay with only battery connected to its winding.

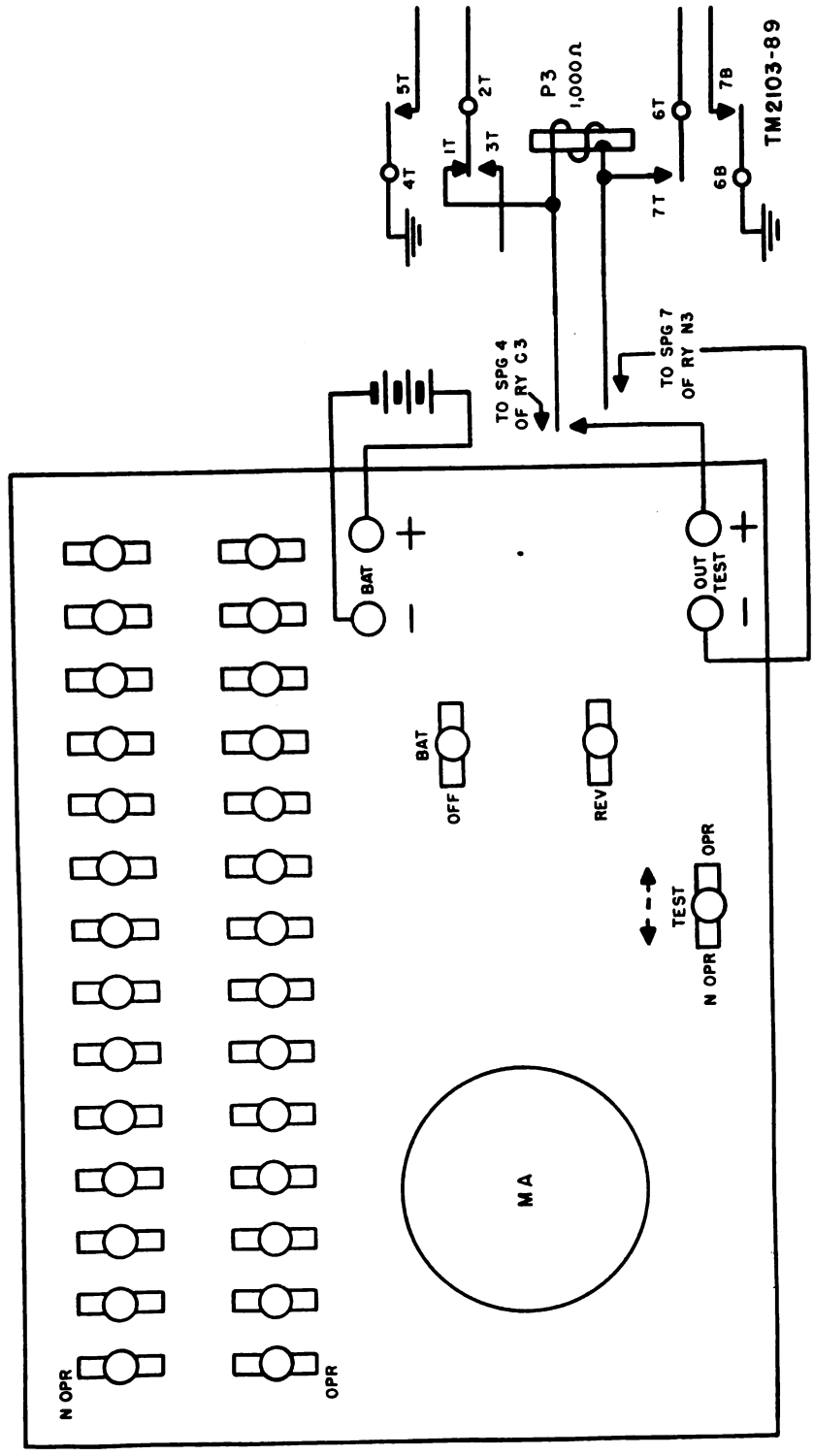

Figure 67. Testing relay with neither battery nor ground connected to its winding.

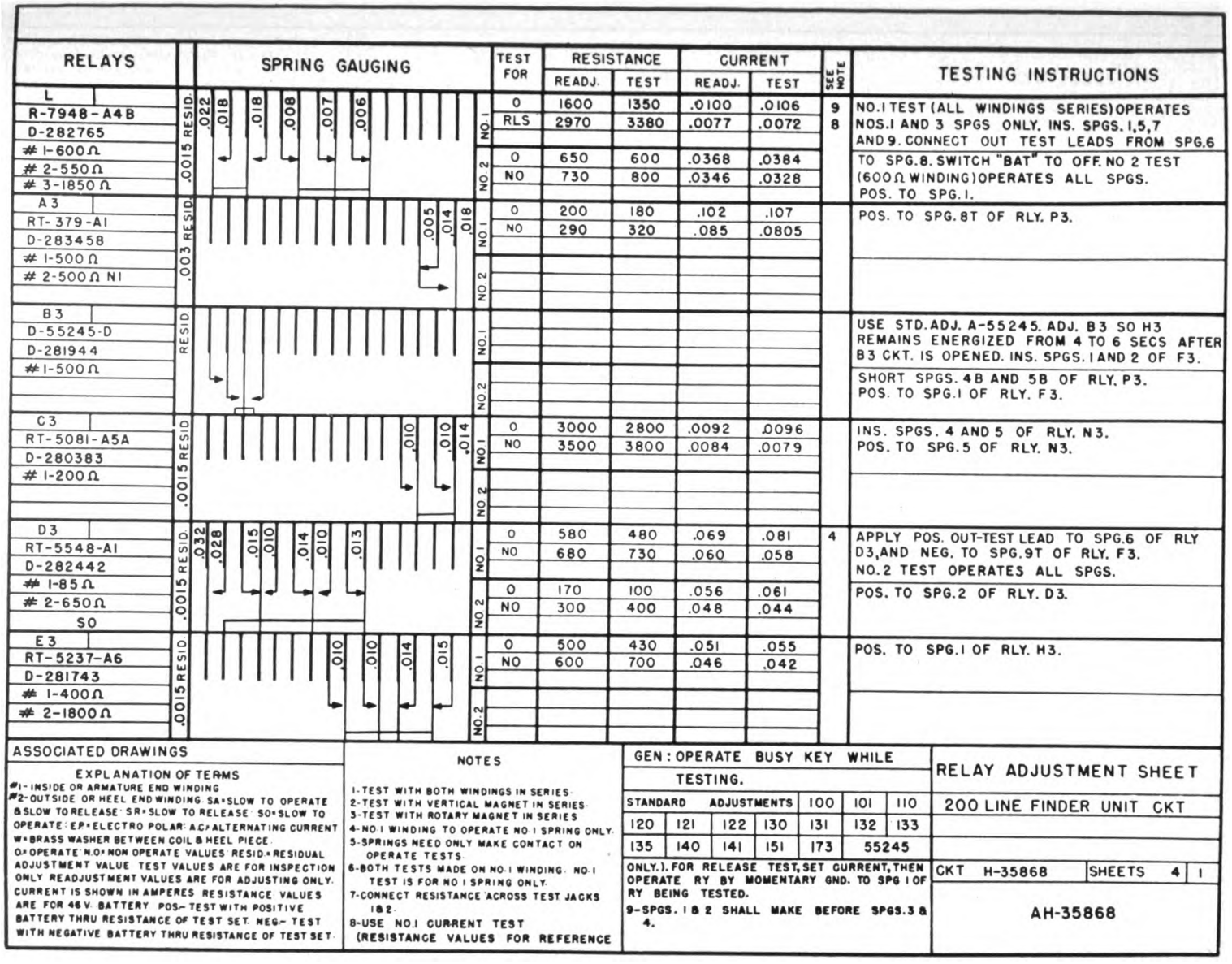

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Figure 68. Typical relay adjustment sheet—Sheet 1 of 4 sheets.

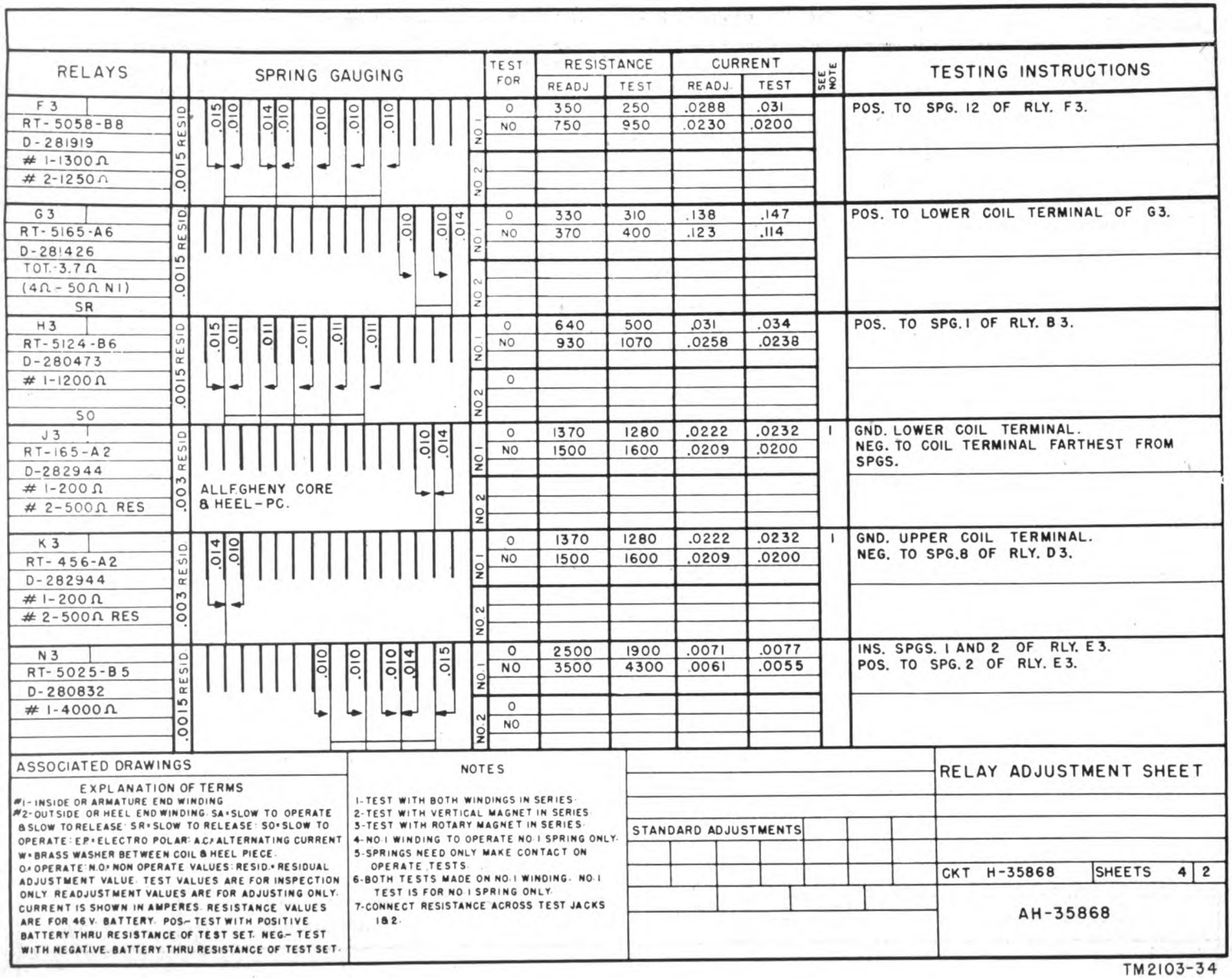


Figure 69. Typical relay adjustment sheet—Sheet 2 of 4 sheets.

RELAYS	SPRING GAUGING	TEST FOR	RESISTANCE READJ	RESISTANCE TEST	CURRENT READJ	CURRENT TEST	SEE NOTE	TESTING INSTRUCTIONS
P3 RT-142-A3 D-280208 # 1-1000Ω DOUBLE ARMATURE RELAY	.0015 RESID: .015 .011 .011 .011 .011	NO 1: 0	1200	1000	.0209	.0230		INS. SPGS. 1 AND 2 OF RLY. F3 AND SPGS. 6 AND 7 OF RLY. N3. APPLY POSITIVE BATTERY TO SPG. 4 OF RLY. C3. NEG. TO SPG. 7 OF RLY. N3.
		NO 1: NO	1800	2100	.0164	.0148		
		NO 2						
	- - - RESID: .015 .011 .011 .011	NO 1: 0						DOUBLE ARMATURE RELAY
		NO 1: NO						
		NO 2						
A R-8798-A1 D-281705 # 1-1300Ω DOUBLE ARMATURE RELAY	.0015 RESID: .006 .006 .006 .006 .011	NO 1: 0	1400	1200	.0170	.0184		INS. SPGS. 1B AND 2B OF RLY. D AND SPGS. 3T AND 4T OF RLY. A. POS. TO SPG. 2B OF RLY. D.
		NO 1: NO	1900	2200	.0144	.0131		
		NO 2: 0						
	- - - RESID: .006 .006 .006 .010 .011	NO 1: 0						DOUBLE ARMATURE RELAY
		NO 1: NO						
		NO 2						
B R-5104-B2 D-281727 TOT-788Ω (1300Ω-2000Ω NI) SR	.0015 RESID: .011 .010 .006 .006 .006 .006 .006	NO 1: 0	900	700	.0273	.031		POS. TO SPG. 8T OF RLY. P3.
		NO 1: NO	1200	1400	.0232	.0210		
		NO 2						
	RESID	NO 1						
		NO 2: 0						
		NO 2: NO						

ASSOCIATED DRAWINGS

EXPLANATION OF TERMS

#1- INSIDE OR ARMATURE END WINDING
#2- OUTSIDE OR HEEL END WINDING. SA= SLOW TO OPERATE & SLOW TO RELEASE: SR= SLOW TO RELEASE: SO= SLOW TO OPERATE: E.P.= ELECTRO POLAR: A.C.= ALTERNATING CURRENT W= BRASS WASHER BETWEEN COIL & HEEL PIECE. O= OPERATE: N.O.= NON OPERATE VALUES: RESID.= RESIDUAL ADJUSTMENT VALUE. TEST VALUES ARE FOR INSPECTION ONLY. READJUSTMENT VALUES ARE FOR ADJUSTING ONLY. CURRENT IS SHOWN IN AMPERES. RESISTANCE VALUES ARE FOR 46 V. BATTERY. POS- TEST WITH POSITIVE BATTERY THRU RESISTANCE OF TEST SET. NEG- TEST WITH NEGATIVE BATTERY THRU RESISTANCE OF TEST SET.

NOTES

1-TEST WITH BOTH WINDINGS IN SERIES.
2-TEST WITH VERTICAL MAGNET IN SERIES
3-TEST WITH ROTARY MAGNET IN SERIES.
4-NO. 1 WINDING TO OPERATE NO. 1 SPRING ONLY.
5-SPRINGS NEED ONLY MAKE CONTACT ON OPERATE TESTS.
6-BOTH TESTS MADE ON NO. 1 WINDING. NO. 1 TEST IS FOR NO. 1 SPRING ONLY.
7-CONNECT RESISTANCE ACROSS TEST JACKS 1&2.

STANDARD ADJUSTMENTS

RELAY ADJUSTMENT SHEET

CKT H-35868 | SHEETS 4 | 3

AH-35868

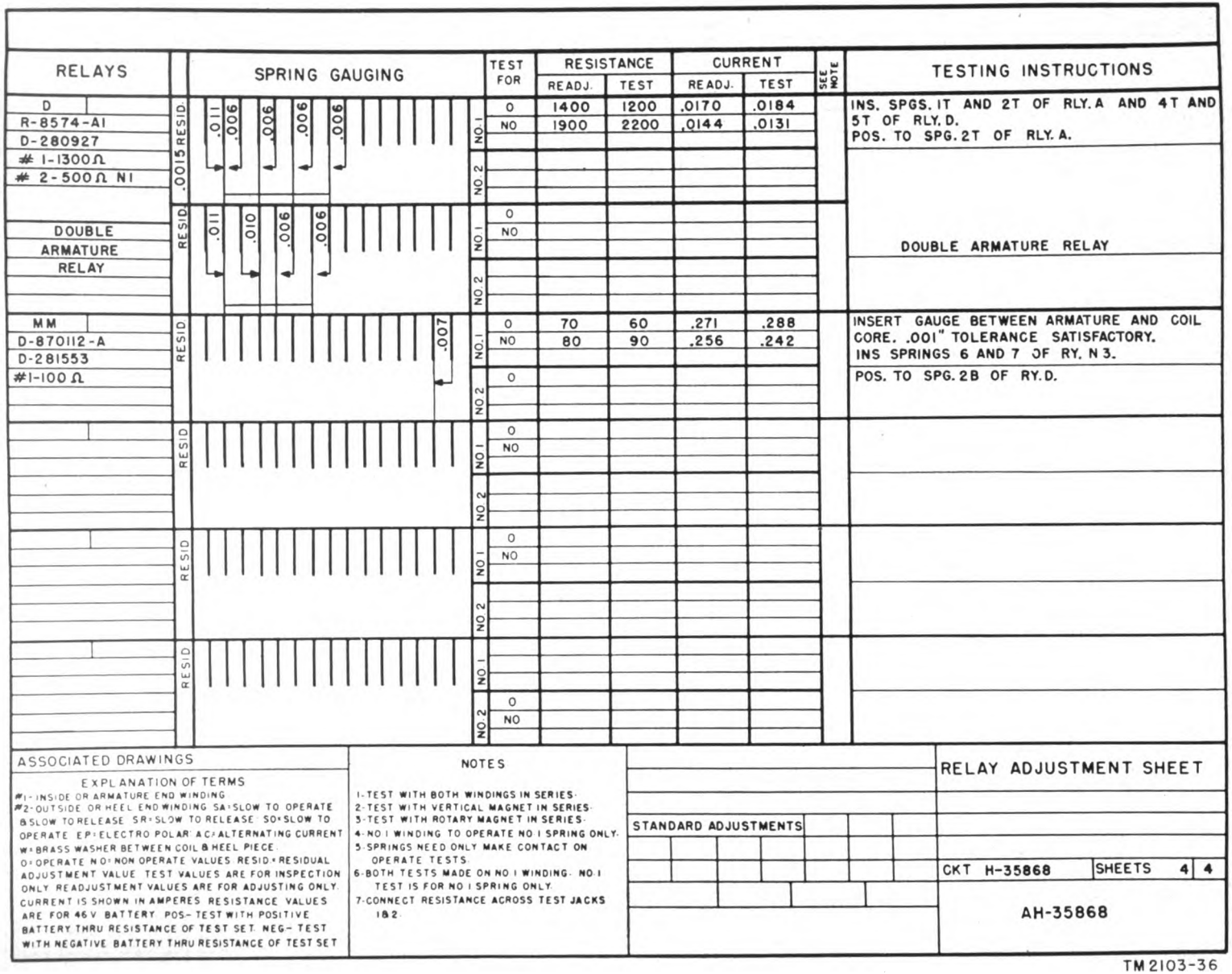


Figure 71. Typical relay adjustment sheet—Sheet 4 of 4 sheets.

(1) Check the relay for loose or bent parts, mechanical defects, contact alinement (fig. 72) and clearance from other relays. Make sure the relay is approximately level, the mounting screws are tight, and that there is at least 1/32-inch clearance between any part of the relay and the closest part of the adjacent relays. Observe the alinement of mating contacts (fig. 72). Maximum deviation allowable is about one-third of the contact diameter, not to exceed 40 percent, judged visually.

(2) Check the residual air gap. The proper residual air gap is listed in the applicable standard relay adjustment sheet (par. 58). The purpose of the residual air gap is to prevent the residual magnetism in the core from holding the armature operated after the current is interrupted. Some relays have fixed residual air gaps, and use a stud instead of a screw. Refer to the applicable standard adjustment sheets.

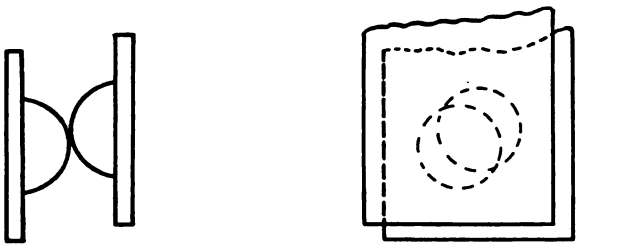


Figure 72. Relay contact alinement.

(3) Check the heelpiece air gap. The standard adjustment sheet issued by the manufacturer for each type of relay specifies the limits of the air gap and tolerances. The heelpiece air gap must be large enough to keep the armature from striking or binding against the heelpiece, but must be as small as possible in order to obtain the maximum magnetic strength. Adjust the heelpiece air gap by loosening the armature yoke screw, inserting the proper thickness gage, and tightening the yoke screw while holding the armature firmly against the gage (par. 60). Always refer to the proper standard relay adjustment sheet (furnished by the manufacturer) for the type of relay being adjusted.

(4) Check the spring gaging. This is the measurement of the movement of the armature or movable contact springs in relation to the stationary or make and break contact springs (fig. 73). Spring gaging is measured between the armature residual screw and the core, with the armature held operated, and observing if the contacts being gaged make or break. The gaging value for each contact is listed on the relay adjustment sheets, in the SPRING GAUGING column (fig. 68). The armature stroke and backstop setting must also be checked when checking or adjusting the spring gaging (par. 60).

(5) Check the electrical operating requirements. Use the current-flow test set (Auto Elec H–64645–1) to test the operate and nonoperate current-flow values listed on the applicable relay adjustment sheet. Connect the current-flow test set to the relay in accordance with directions in the TESTING INSTRUCTIONS column. Use the resistance and current values in the test column.

(*a*) Before testing relays, apply a saturating current to the relay, for at least 1 second, in the same direction as the normal current flow. Do not apply test current to the coil until 1 second after the saturation period. Connect coil windings, having a resistance of 100 ohms or more, directly to the 48-volt main battery. Connect coil windings having a resistance of less than 100 ohms with a 50-ohm protective resistance in series with the voltage source. The resistor banks in the current-flow test set (TM 11–2112) may be used for the purpose.

(*b*) Set the switches in the OPR and N OPR row on the current-flow test set (Auto Elec H–64645–1 and TM 11–2112) to the approximate test resistance value indicated on the relay adjustment sheet. Operate the TEST switch (figs. 65, 66, and 67) to the OPR position. Adjust the total resistance until the meter indicates the specified value of current. Operate the TEST switch several times, observing if the armature operates fully. If armature does not operate fully, the armature (movable or lever) contact springs have too much tension.

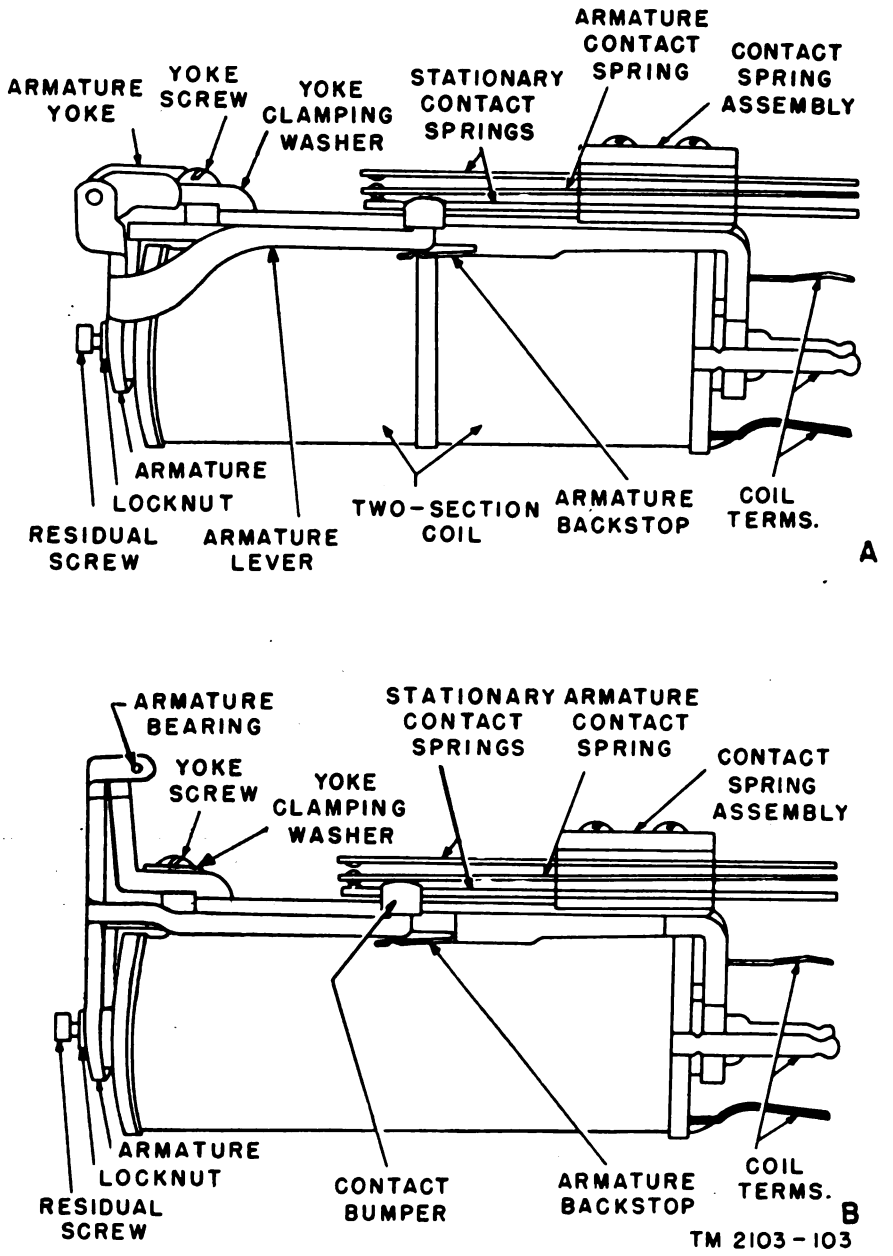


Figure 73. Horizontal-type relays, standard armature (A) and short-lever armature (B), side view.

(*c*) Operate the TEST switch (figs. 65, 66 and 67) to the N OPR position. Adjust the total resistance in the N OPR row of resistance-bank switches until the specified current is indicated on the meter. Operate the TEST switch from normal to N OPR several times, observing whether the armature operates. If the armature operates with the nonoperate value of current flow, the armature springs do not have sufficient tension.

b. Readjust relays that do not meet the spring gaging or the current-flow limits within specified tolerances. Minor variations from specified values are to be expected and are not cause for readjustment. Refer to the manufacturer's standard adjustment sheets for tolerances and adjustment values. Adjust relay contact springs to meet spring gaging require-

ments by bending the stationary contacts with the relay contact spring adjuster (Auto Elec H–20777) (table II and par. 60). Adjust the tension of the movable or armature springs with spring adjuster (Auto Elec H–42873) (table II). For twin-contact type 57 relays, use relay contact spring adjuster (Auto Elec H–88504–1) (table III) for spring gaging, and spring adjuster (Auto Elec H–88504–2) for tensioning springs. Follow the typical procedures and relay adjustment requirements outlined in paragraphs 60–63.

60. Adjustments and Requirements for Horizontal-Type Relays

a. Contact Alinement.

(1) First clean and burnish relay contacts, removing any build-ups (par. 57). Then check the contact alinement by sight. Mating relay contacts must not be out of alinement with each other by more than one-third of their base diameter.

(2) If the relay contacts are not alined satisfactorily, attempt to aline them by applying pressure to the ends of the contact springs. If this does not correct the condition, attempt to loosen the contact spring assembly clamping screws (fig. 74) with an offset screw driver and then to shift the springs as required. Remove the relay from the mounting plate, if necessary, for this adjustment. Tighten the clamping screws securely when the alinement is completed.

Note. Since the clamping screws are tightened under pressure at the factory, then baked and clipped, upsetting the thread and making removal difficult, attempt the contact-alinement procedure described, above and illustrated in figure 74, only in cases of emergency. In any event, if this emergency method is used, *do not force the clamping screws if they do not unscrew easily.*

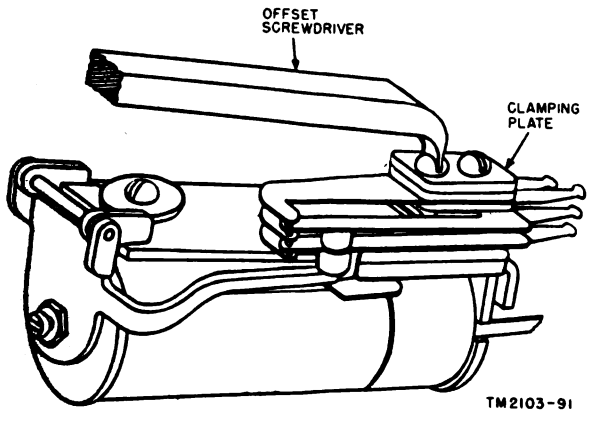


Figure 74. Emergency method of alining relay contacts.

(3) Make sure that relay contact springs do not have any kinks or sharp bends. A gradual bow in the free length of a spring is permissible but should not exceed 0.025 inch. Remove sharp kinks or excessive bows in contact springs with a pair of duck-bill or smooth-jaw pliers (fig. 75) if space permits, or with a spring adjuster, with the proper slot thickness for the spring being adjusted, if space is restricted. Stroke the tool along the contact spring while removing the kink or bow.

Caution: If a spring adjuster is used to stroke a contact spring, be careful that the sharp edge of the slot in the adjuster does not peel a small shaving from the spring. Shavings may cause a short circuit between contact springs which is extremely difficult to locate.

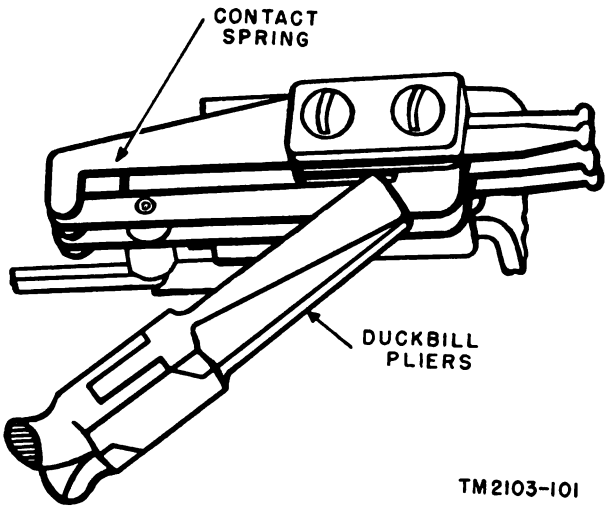


Figure 75. Removing kink in relay contact spring with duck-bill pliers.

b. Heelpiece Air Gap. Check the relay armature to make sure it moves freely in its bearings, without excessive side play. The armature should clear the heelpiece, with an air gap of not more than 0.004 inch for inspection. Measure at the closest point with the armature operated. Loosen the yoke screw. Insert the 0.003-inch thickness gage between the armature and the heelpiece (fig. 76). Shift the armature yoke until the armature presses firmly against the thickness gage. Tighten the yoke screw firmly after completing the adjustment.

Note. For short-lever armature (fig. 77) and slow-release relays, the heelpiece air gap may be 0.005 inch, with a maximum of 0.006 inch for inspection.

c. RESIDUAL AIR GAP (fig. 78). Adjust relays having adjustable residual screws to the value shown on the relay adjustment sheet (par. 58).

(1) A special key-ring type of thickness gage assembly (Auto Elec H–46795–1, Signal Corps stock No. 6R41570, or equivalent), consisting of nine gages mounted on a ring holder, is required for checking the residual air gap, since each gage has a hole at one end. Remove the gages from the holder before using. If this type of gage is not available, use the standard type thickness gage (Signal Corps stock Nos. 6Q45709 or 6Q45726) until the key-ring type thickness gage is obtained. However, checking and adjusting residual air gaps with the standard type thickness gage is difficult and not reliable.

(2) Check the residual air gap (A of fig. 78) by inserting a thickness gage of the specified thickness between the relay armature and the core. Insert the end of the gage

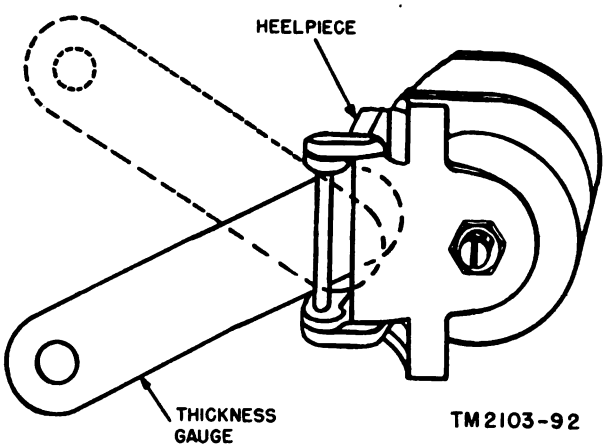


Figure 76. Gaging relay heelpiece air gap on standard armature.

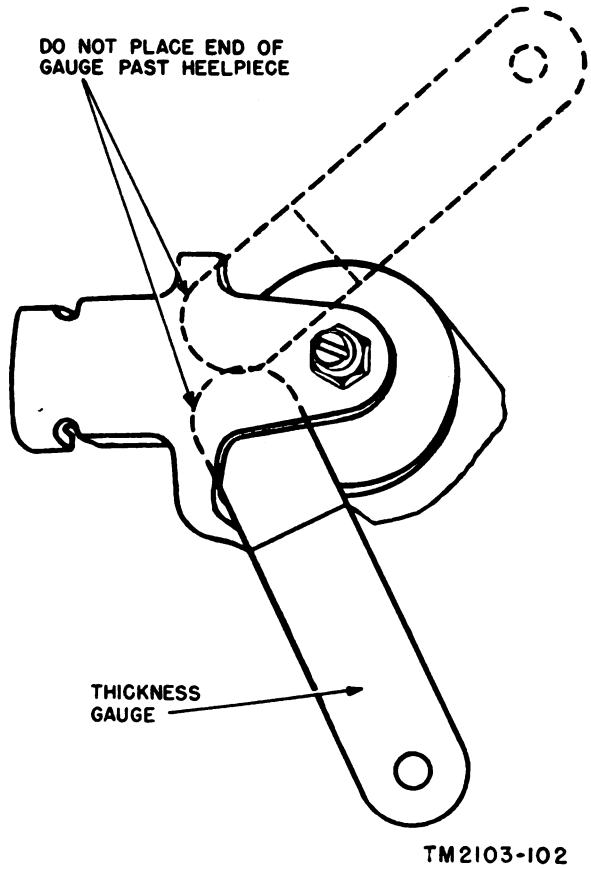


Figure 77. Gaging relay heelpiece air gap on short-lever armature.

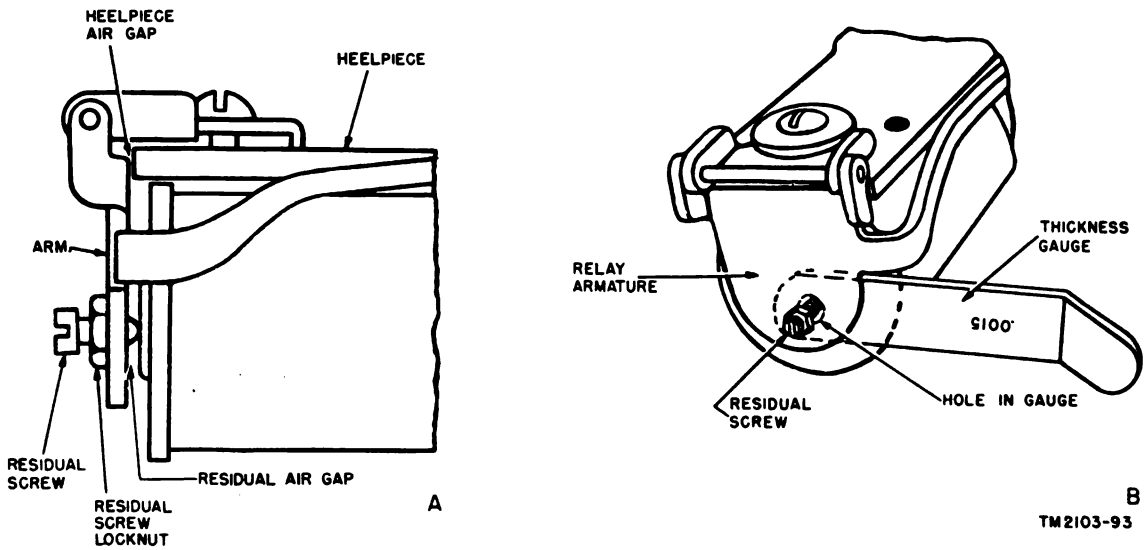


Figure 78. Adjusting relay residual and heelpiece air gaps.

provided with the hole so that the end of the residual screw passes through the hole and strikes the core (B of fig. 78). When using any thickness gage not provided with a hole, insert an end of the gage between the armature and the core, adjacent to, but not touching, the residual screw. Operate the armature, making sure the residual screw touches the core.

(3) Operate the relay armature manually after inserting the proper gage. If the gage is very loose, the air gap is excessive. If the gage is tight, the gap may be too small. Loosen the residual screw locknut (A of fig. 78). Turn the residual screw in or out until the gage fits snugly between the armature and the core. Tighten the locknut securely after completing the adjustment.

d. SPRING GAGING. The values of spring gaging shown on the relay adjustment sheets establish the correct sequence of make or break of relay contacts. Relays must meet the specified values, within tolerances. Check the spring gaging for each contact spring in the relay contact assembly. Relay D–3 in figure 68 is used as an example for the following typical procedure for spring gaging.

(1) Start with the No. 1 contact spring. Using the 9-leaf thickness gage assembly (Auto Elec H–46795–1), insert gages totaling 0.028 inch between the armature residual screw and the core. Operate the armature. Contacts 1 and 2 should just make. If necessary, bend the armature lever to obtain this condition. The stroke is now set. Increase the gage to 0.32 inch and bend the armature backstop so that the gage is snug with the armature in its unoperated position. Reduce the gage to 0.015 inch, and observe that No. 4 contact spring moves far enough to break contacts 3 and 4; and with 0.010-inch gage, observe that contact 4 makes with contact 5. Notice that the break contacts open before the make contacts close, so the circuits are not momentarily interconnected. Repeat the procedure for each contact spring. Minor deviations from the values specified in relay adjustment sheets are not sufficient cause for readjustment. Tolerances for inspection tests are about 0.001 inch for values of 0.003 inch or less, and 0.002 inch for larger values. Readjust relays that show considerable deviation from the specified values. For specific limits and tolerances, refer to the manufacturer's standard adjustment sheet for the particular type of relay being adjusted.

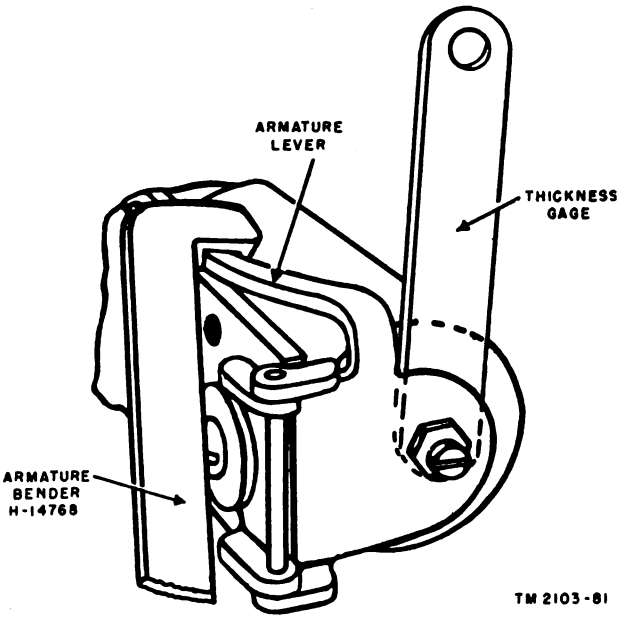


Figure 79. Adjusting relay armature lever.

(2) Check the contact springs for straightness and proper tension. The springs should be approximately parallel to the heelpiece. If necessary, bend the armature lever so that it will operate the No. 1 break contact with the specified thickness gage between the armature and core. Use armature lever adjuster Auto Elec H–14768 (fig. 79). If the relay contact pile-ups do not have break contacts, adjust the armature stroke to the gaging value shown for the No. 1 contact by bending the armature backstop, using armature stop bender Auto Elec H–14769 (fig. 80). When Nos. 1 and 2 contacts

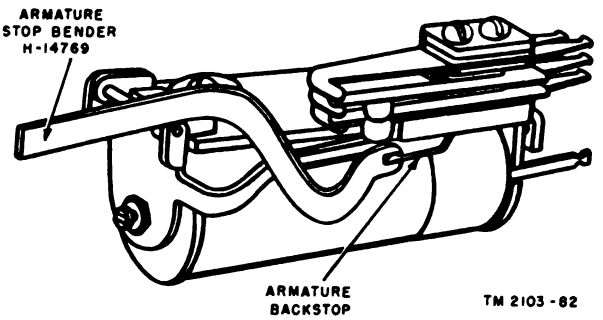


Figure 80. Adjusting relay armature backstop.

are break contacts, the armature backstop should clear the armature when the armature is at rest. Adjust the armature backstop (fig. 80) if necessary, with the armature lever adjuster, until a perceptible gap, 0.005- to 0.012-inch, is obtained.

(3) Adjust the stationary contacts, when necessary, to meet the gaging requirement. Use spring adjuster Auto Elec 20777 for horizontal relays, or duck-bill pliers when the springs are easily accessible. Use spring adjuster Auto Elec H–88504–2 for type 57 twin-contact relays.

(4) When the relay contact assembly has more than one set of break contacts, adjust the armature (movable) contact springs so that the armature breaks each set in sequence instead of simultaneously. Adjust the contact spring closest to the armature to break first, the next nearest contact spring to break second, and any other contact springs in order. This permits the armature to pick up the spring loads one at a time; and, in restoring, each contact rests against its mating contact with full tension.

e. Spring Tensioning.

(1) Adjust the tension of armature springs of relays that do not meet the TEST limits in the current-flow test (par. 59). If the relay operates on the nonoperate test, increase the armature spring tension. Using spring adjuster Auto Elec 42873, engage the spring in the slot in one end of the spring adjuster, at a point near the insulator (fig. 81). Bend the spring toward the heelpiece. Perform this adjustment for each armature spring in the relay contact assembly, taking care to distribute the tension evenly. Do not put too much tension in the springs, or the relay will not operate on the operate test. The tension adjustment may change the spring gaging. Recheck the spring gaging, then test for operate and nonoperate requirements with the current-flow test.

(2) If the tensioning adjustment does not result in sufficient spring tension, return the spring to its original shape by removing bends or kinks. Place the spring adjuster (fig. 81) on the desired armature or movable spring close to the clamping plate, near the terminal end of the relay. Turn the spring adjuster in such a direction as to move the armature spring away from the heelpiece, bending it slightly. The armature spring will no longer make contact with its break (stationary) contact.

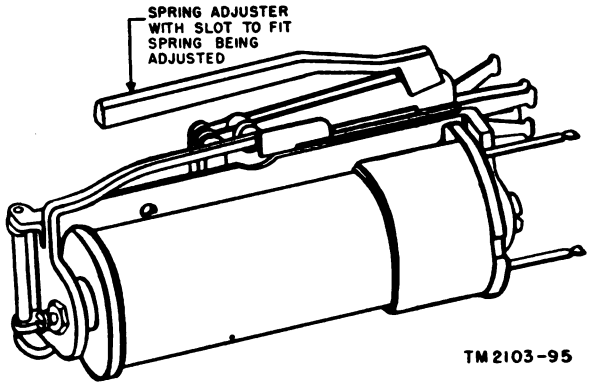


Figure 81. Adjusting relay armature contact spring tension.

(3) Stroke the armature contact spring, by sliding the spring adjuster Auto Elec 42873 along the spring while pressing the spring slightly upward and with the tool held at an angle with respect to the spring. This action will arch the spring away from the heelpiece, with the concave surface of the bowed spring facing the heelpiece. The center of the bowed spring will be farther away from the heelpiece than either the clamped or the contact end. Take care not to place sharp bends or kinks in the spring.

(4) Now bend the armature spring back toward the heelpiece, placing the adjusting tool on the spring in the same location as before. Bend the armature spring until the contacts rest against its break (stationary) contacts with sufficient pressure to remove the slight bow from the spring. The relay armature will now operate against greater spring tension.

(5) If the relay failed to operate on the operate test, or when too much tension is put in the armature springs during adjustment, bend the armature springs slightly away from the heelpiece to reduce the tension.

(6) Adjust twin-contact relay springs carefully so that both contacts remain alined and make at nearly the same time. If both contact pairs do not make fully within the limit of spring gaging tolerance, adjust the springs until this requirement is met.

f. RELAY ADJUSTMENT REQUIREMENTS. Always refer to the manufacturer's standard adjustment sheets for the adjustment requirements and tolerances. Following are examples of requirements and tolerances for horizontal-type relays listed in the standard adjustment sheets.

(1) The relay armature must move freely in its bearings with side play of not less than 0.002 inch or more than 0.020 inch. The armature must not make contact with the heelpiece, but must clear it by not more than 0.003 inch for adjustment, and 0.004 inch for inspection. Measure at the closest point with the armature operated (par. 59).

Note. For short-lever armature and slow-release relays, the maximum heelpiece air gap may be 0.005 inch for adjustment and 0.006 inch for inspection.

(2) Adjust the armature backstop to allow a perceptible clearance (0.005 to 0.012 inch) in the armature between the No. 2 contact spring and the armature backstop on contact assemblies where the No. 1 contact spring is a break contact.

(3) Adjust relays equipped with residual screws to the residual air gap specified on the relay adjustment sheet.

(*a*) When the relay adjustment sheet specifies a residual air gap of 0.003 inch or more, a maximum tolerance of 0.001 inch for adjustment, and 0.002 inch for inspection, may be allowed.

(*b*) When the residual air gap is specified as 0.0015 inch, the armature must not touch the core, or be farther from the core at the closest point than 0.003 inch for adjustment, 0.004 inch for inspection, with the relay electrically operated.

(4) When the armature travel (stroke) value is specified on the relay adjustment sheet, a tolerance of 0.002 inch for inspection may be allowed. A 0.003-inch gage greater than the armature travel value should not enter between the end of the residual screw and the coil core on standard armature relays. For short lever armatures, use a 0.005-inch gage. Check with the relay not energized. If the gage enters, the armature should not leave the armature backstop when the relay is energized.

(*a*) If the requirement is not met, adjust the armature lever with armature bender Auto Elec H–14768 (fig. 79). Adjust with the specified thickness gage inserted between the armature and the coil core.

(*b*) When the difference between the specified armature travel and the highest value for make contact spring gaging is 0.005 inch or more, insert a thickness gage of 0.002 inch less than the values specified for the armature travel between the armature and the core, and note that the armature leaves the backstop when the relay is operated.

(*c*) When the difference between the values specified for the armature travel and the highest value for make contact gaging is 0.004 inch or less, insert a thickness gage of 0.002 inch more than the value on which the make contact actually makes, between the armature and the core, and note that the armature leaves the backstop when the relay is operated.

(5) Adjust relays, when required, to the spring gaging requirements specified on the applicable relay adjustment sheet. The spring gaging requirements is checked by placing a thickness gage of the specified value between the relay armature residual screw and the core of the coil. Operate the relay electrically or mechanically and observe that contacts make or break, within allowable tolerances.

(*a*) Make contacts should not make with the plus tolerances, and should make with the minus tolerances; break contacts should not break with the plus tolerances and should break with the minus tolerances.

(*b*) For inspection, a plus or minus 0.001-inch tolerance for standard armatures, or plus or minus 0.002-inch for short lever armatures may be allowed, except that on values of 0.004 inch or less the tolerance is 0.001 inch.

(*c*) Twin-contact relays may have one of the contact pairs making before the other contact pair. In this case, when the first contacts make, the other contacts may have a barely perceptible clearance, and must make fully within the maximum spring gaging tolerance.

(6) Relays must fully operate all contact springs, and the armature residual screw (when used) must touch the magnet core,

on the OPERATE tests shown on the relay adjustment sheet.

(*a*) Relays should not open any break (back) contact circuits or close any make contact circuits on the NON OPERATE tests shown on the relay adjustment sheet, except on relays having three or more break contacts. In this case, the first two break contact combinations in the operating sequence may break contact on the NON OPERATE tests. This exception *does not apply* to break contacts of the standard make-before-break combinations illustrated by Nos. 2 and 3 springs (A of fig. 82). This requirement *does apply* to the break contacts of the special make-before-break combination illustrated by Nos. 1 and 2 springs (B of fig. 82).

(*b*) On special make-before-break combinations, (B of fig. 82) the make contacts may make on the NON OPERATE requirements specified for the entire contact spring assembly.

(*c*) On two-step relays, the contacts to which the separate electrical requirements apply make or break on the NON OPERATE requirements specified for the entire contact spring assembly.

(*d*) Contact spring tension will be inspected in accordance with the TEST values given on the relay adjustment sheet, and adjusted in accordance with the READJUST values.

(7) Before testing or adjusting relays, apply a saturating current to the relay for at least 1 second. The saturating current flow must be in the same direction as the normal current flow. Do not apply test current to the coil until 1 second after the saturation period.

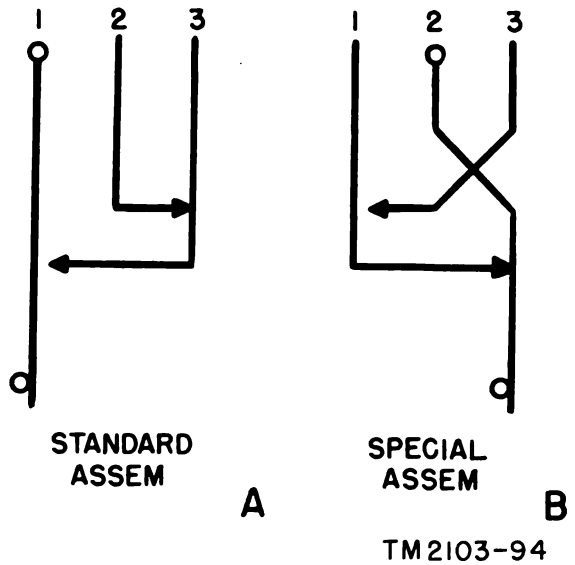


Figure 82. Relay contact spring assemblies, make-before-break

61. Two-step Relays (figs. 83 and 84)

a. Two-step operation of a standard horizontal relay is obtained by a combination of magnetic field strength and spring tension. The circuit is so designed that the pull of the relay coil is limited sufficiently, on No. 1 step, to move the relay armature, against the tension of the spring pile-up, through only that part of its travel required to operate the contact springs associated with No. 1 step. No. 2 step is completed by increasing the magnetic field strength of the relay coil sufficiently to move the armature through the remainder of its travel, operating the rest of the contact springs.

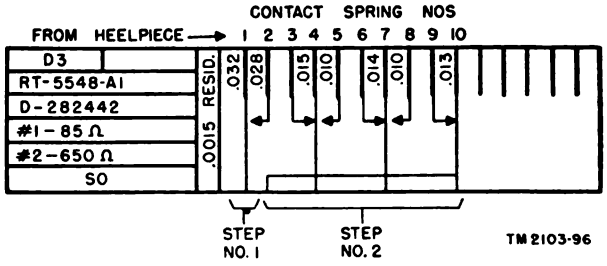


Figure 83. Relay adjustment data for two-step operation.

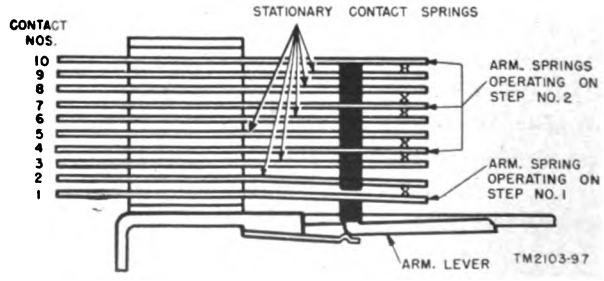


Figure 84. Relay contact assembly for two-step operation.

b. Horizontal relays having two-step operation are normally marked as such on the circuit drawing, and are sometimes so designated on the relay adjustment sheet. This type of operation can be determined easily from the adjustment sheet by examining the contact spring arrangement, or by inspecting the actual relay contact spring assembly.

c. Testing two-step relay operation usually requires the testing of two coil windings with the current-flow test set. First, check the residual air gap and the heelpiece air gap. Then check the gaging requirements, which include the checking of armature travel. Connect the current-flow test set to the relay winding for the first test. Check for proper operation of springs associated with No. 1 step. Connect the current-flow test set to the winding used for No. 2 step and check for proper operation of springs associated with the No. 2 step. Springs associated with No. 1 step are permitted to close on the nonoperate value of No. 2 step. Follow the instructions given in the TESTING INSTRUCTIONS column of the relay adjustment sheet.

(1) Using relay D–3 in figure 68 as an example, connect the positive out-test lead of the current-flow test set to contact spring 1 of relay D–3, and connect the negative out-test lead to contact spring 9T of relay P–3. This connects the current-flow test set to No. 1 coil of relay D–3. Test operation of contacts 1 and 2 using the current-flow values listed on the adjustment sheet in the TEST column for the No. 1 test. Adjust Nos. 1 and 2 springs if necessary, to meet the operate and nonoperate requirements. If adjustments are made, retest, using current-flow values in the READJ. column.

(2) After completing the test on the first step, change the test connections for No. 2 test. The instructions for the No. 2 test state POS to SPG 2 of relay D–3 and do not give any connection for the negative out-test cord. The test connections for the second step will therefore be similar to figure 66. Test for operation of all contacts, using the values listed in the TEST column on the adjustment sheet for No. 2 test. If any adjustments were necessary to meet the requirements, retest, using current-flow values in the READJ. column. Also recheck the first step to make sure the initial adjustments have not been thrown off.

62. Vibrating-reed Timing Relays (fig. 85)

a. Adjust timing relays in the position in which the relays are mounted in operation. Make sure that the contact assembly mounting screws are tight. Position the vibrating reed so that the horizontal center line of the pendulum slot is in line with, or slightly above, the center line of the core, and when electrically operated, the pendulum weight strikes the core squarely, as gaged visually.

b. No. 1 contact must have a minimum follow of 0.010 to 0.015 inch, with the relay energized and the pendulum resting against the core, as gaged visually. The tension of Nos. 2 and 4 contact springs must be 7 to 12 grams with the adjusting screws set to give a contact separation of 0.004 to 0.008 inch.

c. Adjust the cycle time to the circuit requirements. The cycle time may be reduced by increasing the contact separation to a maximum value of 0.048 inch with an incidental increase in spring tension.

d. The angle of the end of a spring may be changed if necessary, where it makes contact with the buffer of the adjusting screw. The side of the contact spring should be tangent to the buffer at the point of contact. Both the insulating bumpers on No. 3 contact spring must not have tension against the reed. Any clearance between either bumper and the reed should be barely perceptible.

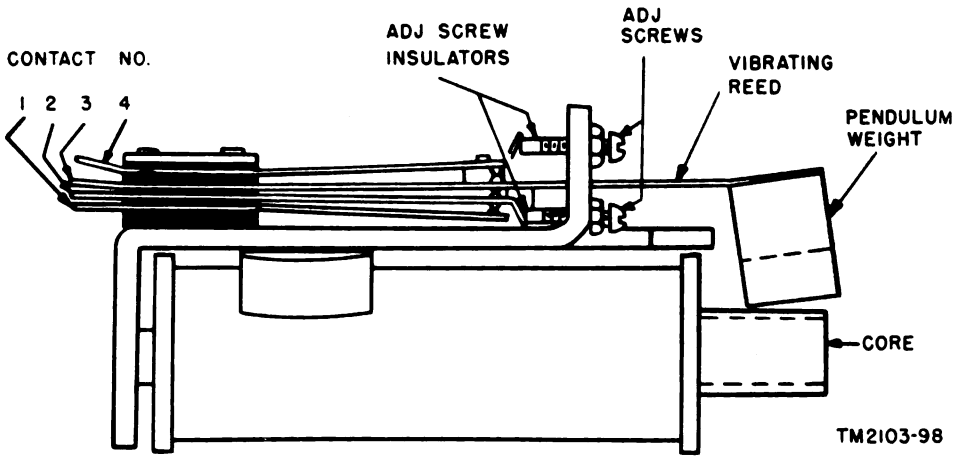


Figure 85. Vibrating-reed timing relay, top view.

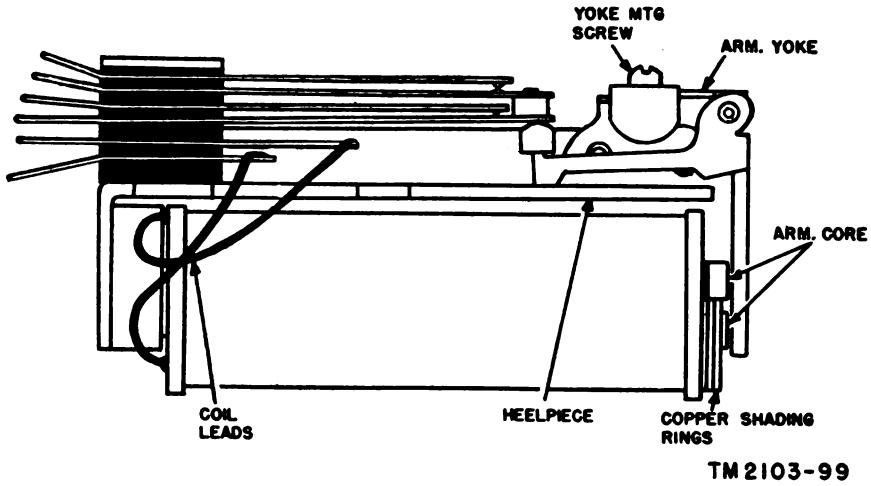


Figure 86. Type No. 10 a-c relay.

63. A-c Relays (fig. 86)

a. Typical a-c relays (Auto Elec type No. 10) have a U-shaped laminated core with the magnet coil mounted on the lower leg of the core. Copper *shading* rings, to eliminate armature hum or chattering, are mounted on the armature end of the coil core. The relay has a conventional armature assembly consisting of the armature, armature yoke, and armature bearing pin. The residual gap is fixed, using a brass stud. The contact spring assembly is mounted on the brass heelpiece. Note that Nos. 1 and 2 terminals in the contact assembly are connected to the coil leads. This makes the coil terminals readily accessible when testing, unlike the conventional coil terminals used on horizontal relays which are reached from the rear. Remember this when following the TESTING INSTRUCTIONS on the relay adjustment sheet.

b. In general, the inspection and adjustment procedure is similar to that for d-c relays of the horizontal type. When it is necessary to test and adjust an a-c relay to meet the electrical and contact spring gaging requirements, refer to the applicable adjustment sheet covering the circuit in which the relay is used.

c. A few differences in specific requirements for a-c relays are noted as follows:

(1) With the armature operated, there must be perceptible clearance between the armature and the face of the core and heelpiece at all points, but this clearance must not exceed the clearance caused by the fixed armature residual stud. Adjust, if necessary, by loosening the armature yoke mounting screws (fig. 86) and shifting the yoke. Tighten the screws securely after completing the adjustment. At least half of the residual surface should appear to be in contact with the core when the armature is fully operated. To adjust, loosen the armature yoke mounting screws, adjust the armature position, and tighten the screws securely.

(2) When the armature travel (stroke) values are specified on the relay adjustment sheet, the tolerance is plus or minus 0.002 inch. When checking the stroke, place the proper thickness gage between the residual stud and the core so that the blade will cover the core but will not project more than one-sixteenth inch beyond the core toward the heelpiece. Energize the relay. Adjust the armature lever as required with an armature bender or long-nosed pliers to meet the requirements.

(3) Check the spring gaging requirements specified on the relay adjustment sheet by placing the proper thickness gage between the residual stud and the core. Energize the relay and observe that the contacts make or break within the specfied values. Adjust the contact springs to meet the requirements.

(4) In contact spring assemblies having no break contacts, the tension of the armature springs should be approximately equal. The tension of any armature spring against the armature bumper, or the preceding armature spring, must be a minimum of 10 grams.

Section III. REPAIR PROCEDURES

64. Replacement of Parts

a. GENERAL. Most of the equipment faults occurring in the dial central office are corrected by adjustments. When parts are damaged or excessively worn, or electrical apparatus has failed, make repairs or replacements. Use new parts instead of repairing old ones, since reliability of the equipment is the most important consideration. When new parts are not available, old parts may be repaired to keep the equipment operating until the parts can be obtained. Following are general procedures for repairing the switching equipment in dial central offices. Refer to TM 11–2108 for repairs to the batteries, and charging, ringing, and control equipment.

(1) *Identification of leads.* Before removing parts, unsolder and tag each wire, and make a record of its original position. When replacing repaired or new parts in the equipment, make sure that wires are replaced in their original position.

(2) *Electrical connections.* When replacing wiring, cut the new leads to the lengths required for proper dressing and for satisfactory connection. Do not use more solder than necessary for a good connection, and be careful not to drop solder on other parts. Hold the soldering iron on the connection to be soldered only long enough to secure a good connection. Do not char insulating material by applying excessive heat.

b. RELAYS. Defective relays that cannot be made serviceable by readjustment, by contact burnishing, or by performing minor repairs should be replaced. Make no attempt to replace any of the contacts in the contact pile-up. Relay armatures should rarely require replacement. In this case, a repaired part may be used. Relay coils may be replaced, but if the relay has had long service and shows wear of contacts, it is best to replace the entire relay. When replacing coils, *make sure* that the new coil is identical to the one being replaced. The manufacturer's part number, and sometimes the coil resistance, is stamped on the spoolhead. Do not replace slow-acting relay coils having copper *slugs* (collars) with coils not having them, unless it is known that the new coil is also designed for slow-acting relays. (Some relay coils have copper sleeves on the cores which are not visible, and this type of coil is frequently substituted for the slug-type coil used in slow-acting relays.) When replacing relays, unsolder the connections from the coil and the contact assembly one at a time, and carefully tag each wire with its terminal number. Remove the two mounting screws securing the relay to the base, replace the relay, and carefully solder the wires to the proper terminals. Test the operation of each relay, and the equipment containing replaced relays, before returning it to service. Add the circuit designation letter, that was marked on the armature of the old relay, to the new relay. Use a lettering kit or any suitable brush, and ink or paint the letter clearly on the relay armature.

c. METERS. Meters are extremely delicate and must be handled carefully. Adjustment and repair should be made only by qualified personnel. When tests indicate the need for meter repair, replace the meter or send it to a repair depot. Ammeters are calibrated with their associated shunts. When sending a meter for repair, also remove the shunt from the circuit and send it with the meter, in order that it can be adjusted accurately. When removing an ammeter for minor adjustment, the shunt may be left in the circuit to permit temporary operation of the equipment.

d. RESISTORS. Be careful in disconnecting spool-type wire-wound resistors. Excessive heat applied to the terminal when soldering may cause permanent damage to the resistor. Spool-type resistors are usually precision-wound and should be replaced with a resistor of the same type and resistance. The resistors frequently have a letter marked on the outer covering, for circuit designation. When installing a new resistor, mark it with the same letter noted on the replaced resistor. The resistors are mounted by means of a screw through the spool center. Sometimes several resistors are stacked, with one long mounting screw for the stack. When replacing one of the resistors, remove the mounting screw and unsolder the wiring to only the resistor which is being replaced. Place the new resistor in the same position in the stack previously occupied by the old one.

e. CAPACITORS. Test capacitors with a volt-ohm-milliammeter, using the HI-OHMS scale. Replace any capacitor that shows leakage on test, or that has intermittent open circuits. Remove the wires carefully and tag each according to its location. Remove the capacitors from the mounting bracket and install the new capacitor in the same relative position as the old one. Be careful in soldering wires to the terminals, as the capacitor is easily damaged by excessive

heat. Mark the new capacitor with the same circuit designation letter noted on the old capacitor.

f. Lever Switches. Lever switches, usually called *keys,* are mounted to the escutcheon plates by four machine screws. To remove a lever switch, unscrew the plastic switch handle, and remove the four mounting screws. The switch then can be withdrawn from the rear of the panel. Frequently the wires leading to the switch are long enough to enable the switch to be positioned for ready access to the terminals. When installing the new switch, each wire may be placed on the proper terminal of the new switch as it is removed from the old one. If this cannot be done, tag each wire with suitable identification.

g. Dials. When a dial cannot be made serviceable by readjustment, replace it. Remove the dial from its mounting by removing the screws from the rim of the mounting and lifting the dial mechanism from the mounting. Replacing a dial used in the step-by-step dial central office equipment (but *not* in telephone user's equipment) does not require changing any wiring connections. The dial interrupter contact assembly may be removed from the dial assembly for replacement, but local repair of the dial mechanism is not recommended. Return defective dials to a repair depot.

h. Switch Connectors and Shelf Connectors. The connectors mounted on the switch shelves are commonly termed *shelf jacks* and the mating connectors on switches are termed *switch jacks.* If trouble is experienced with the contacts of either type of connector, replace the connector. Temporary repairs may be made by disassembling a connector, removing the faulty contacts, and reassemb-

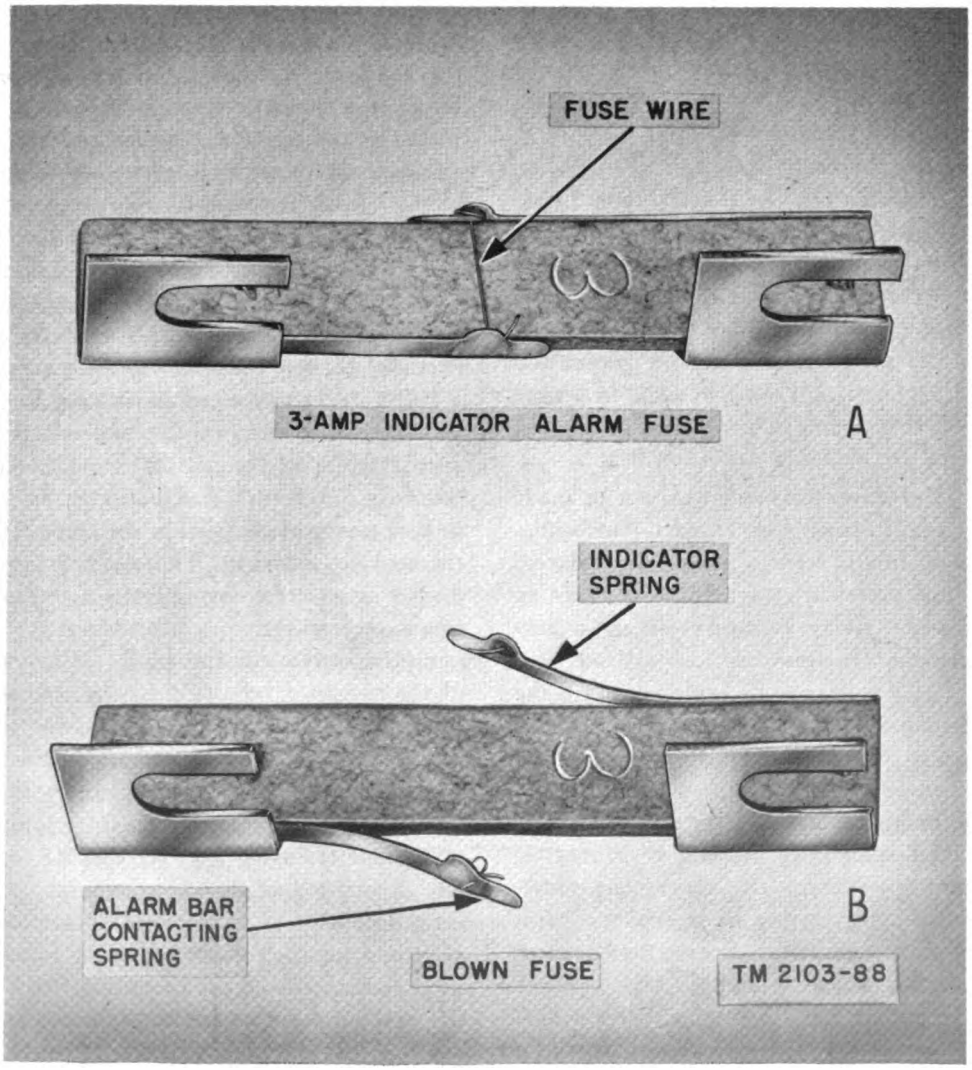


Figure 87. Indicator-alarm fuses.

ling, making use of the contacts not required for operations of the circuit, for substitution in place of the faulty contacts.

i. Fuses. When a fuse has blown, check the circuit to determine the cause of the fuse failure, and clear any troubles found before replacing the fuse. Wherever feasible, disconnect the power from the circuit before removing the blown fuse and installing the new one. Power fuses of high rating usually have indicator-alarm fuses associated with them. After replacing the power fuse, also replace the indicator-alarm fuse.

j. Repairing Indicator-Alarm Fuses. Indicator-alarm fuses are used in circuits requiring fuses of 5-ampere or lower rating, and also as indicator fuses in main power circuits. When the fuse wire of an indicator-alarm fuse burns out, its springs move apart. One spring contacts the alarm bar or stud, closing the alarm circuit and actuating the power board alarm bell or buzzer. The other spring of the fuse serves as an indicator to identify the blown fuse (fig. 87). Indicator-alarm fuses must be replaced with a fuse of the same rating. The rating is marked on each fuse. The numeral 3 on the fuse in figure 87 indicates it is a 3-ampere fuse. Indicator-alarm fuses may be repaired by replacing the fuse wire.

(1) To repair a fuse, use fuse repair kit Auto Elec H–14315. This kit contains the necessary fuse wire, and the hard solder and special flux required.

(2) Place the fuse in a vise, using small blocks of wood between the vise jaws and the fuse, or construct a jig of small wood blocks so arranged to hold the springs tightly against the body of the fuse.

(3) Use a soldering iron capable of supplying sufficient heat. A 100-watt or 150-watt electric soldering iron should be satisfactory. Apply the soldering iron to the soldered fuse wire connections. Remove excess solder and the ends of the fuse wire.

(4) Use fuse wire of the proper rating for the fuse being repaired. Pass the wire through the holes in the springs. Bend about one-eighth inch of the wire ends over each spring. Apply a small amount of the special flux. Heat the connection with the soldering iron, apply enough solder to make a good connection, remove the iron when the solder has flowed evenly, and allow the soldered connection to cool enough to harden completely before removing the fuse. Cut off the excess ends of the fuse wire.

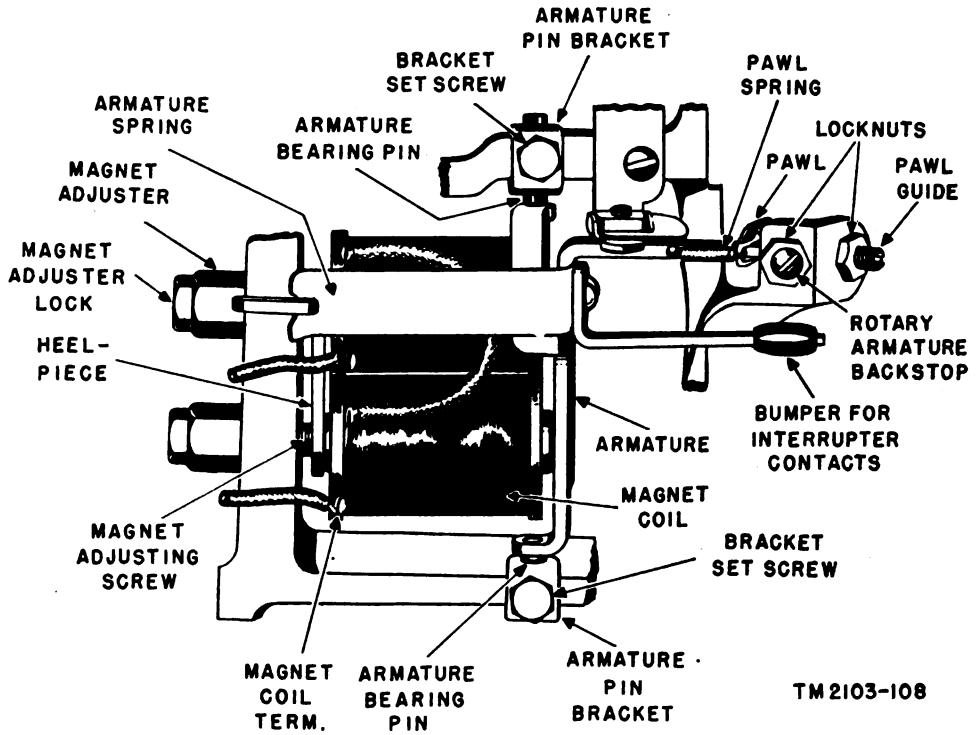


Figure 88. Rotary stepping mechanism of two-motion stepping switch.

65. Two-motion Stepping Switch Repairs

a. Replacing Parts in the Rotary Stepping Mechanism.

(1) *Rotary armature bearing pin bracket and bearing pin or armature assembly* (fig. 88). Lift the end of the rotary armature restoring spring from the T-head adjusting screw. Loosen the lower bearing pin bracket screw. Remove the lower bearing pin by pulling the pin down through the hole in the lower cover plate. Remove the bearing bracket.

(2) *Rotary armature assembly.* If the armature assembly or the upper bearing pin is to be replaced, loosen the upper bearing pin bracket screw. Push the bearing pin up far enough to release the armature. Remove the armature. Then push the pin back through the hole to free the bearing bracket. Remove any protective lubricant from the new parts with solvent (SD), and wipe dry. Replace the upper bearing pin and bracket, pushing the pin through far enough to permit the insertion of the armature, and replace the armature. Make sure that the rotary pawl passes between the rotary pawl front stop and pawl guide, and that the arm of the armature is in the proper position to operate the interrupter springs (if used). Replace the lower bearing pin and bracket. Insert the ends of the upper and lower pins in the holes in the armature. Tighten the bracket screws just enough to hold the pins in place. Check the position of the armature on the rotary backstop screw. If not centered, shift the armature and bearing pins until centered. Tighten the bearing bracket screws securely. Engage the end of the armature restoring spring under the head of the adjusting screw. Lubricate in accordance with lubrication instructions in paragraph 21.

(3) *Rotary pawl spring* (fig. 89). Unhook the closed end of the spring from the retaining pin on the armature with a pair of tweezers or other suitable tool. Unhook the open loop from the pawl. Hook the open loop of the new spring in the pawl with the open side facing outward. Place the closed loop of the spring over the pin on the armature. The tension of the new spring should be sufficient to hold the pawl securely in its extreme forward position.

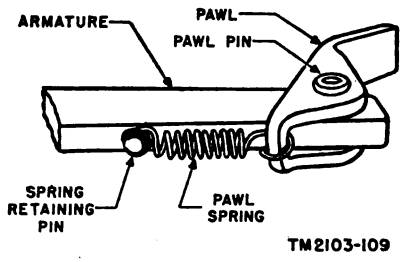


Figure 89. Rotary pawl and pawl spring.

(4) *Rotary pawl and pawl pin.* In cases of emergency when the rotary pawl must be replaced, first remove the rotary armature and the rotary pawl spring. Hold the armature securely, and file off the flared end of the pawl pin (fig. 90). Perform this operation carefully in order to avoid deforming the rotary armature assembly. Use a punch, with diameter smaller than the pawl pin, and a soft-faced hammer. Place the punch against the filed end of the pawl pin and gently drive it out of the pawl. Replace the pawl and pawl pin. Flare the end of the new pawl pin.

Note. Follow the procedure outlined above as an emergency repair operation only. Preferably replace the entire armature assembly, including the defective rotary pawl.

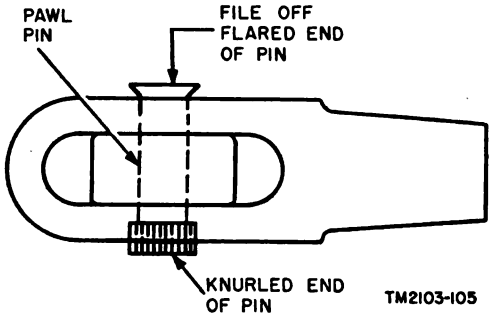


Figure 90. Emergency method of replacing defective rotary pawl and pawl pin.

(5) *Rotary pawl front stop and adjusting screw.* Raise the switch shaft to the tenth vertical level. Remove the front stop mounting screw and the front stop. Remove the stop adjusting screw. Insert the new stop adjusting screw. Turn the screw into the frame approximately three-quarters of its length. Mount the new front stop and insert the stop mounting screw. Tighten the screw only enough to hold the

stop in place. Adjust the stop to its specified position (par. 48) with the stop adjusting screw. When adjustment is completed, tighten the mounting screw securely.

(6) *Rotary pawl guide and armature backstop.* Loosen the locknut holding either the guide or the backstop. Unscrew the stop or guide and replace with a new stop or guide. Adjust to the proper position (par. 48). Tighten the locknut securely when the adjustment is completed.

(7) *Rotary interrupter and cam contact spring assembly.* Unsolder the leads to the spring assembly to be replaced. Remove the two mounting screws that hold both mounting brackets on the switch frame. Replace the defective spring assembly. Mount the two assemblies by placing the lugs of the cam spring assembly mounting bracket over the interrupter spring mounting bracket. Line both brackets up with the holes in the switch frame. Replace the mounting screws and tighten securely. Attach the leads to the proper terminals and resolder.

b. Replacing Vertical or Rotary Magnet Coils. Tag, then unsolder the leads at the coil terminals. Loosen the coil by unscrewing the hexagonal-head locking screw, turning it in a counterclockwise direction until the coil is free. Remove the coil. Place the new coil in position, and locate it so that the coil terminals on the spoolhead are in the same position as were those of the removed coil. Insert the locking screw into the threaded hole in the magnet core. Tighten by turning in a clockwise direction. Make sure that the heelpiece is in its proper position, then tighten the locking screw firmly. Fasten the leads to the coil terminals and solder securely.

c. Replacing Parts in Release Mechanism.

(1) *Release magnet.* Tag, then unsolder the leads connected to the terminals of the magnet coil. Lift the release armature from the lugs in the magnet bracket. Remove the release magnet mounting screw and withdraw the magnet from the right-hand side of the switch. Place the new magnet in position, with the terminals on the spoolhead pointing toward the rear of the switch. Insert the magnet mounting screw and tighten securely. Attach the leads to the magnet coil terminals and resolder. Replace the release armature on the lugs on the mounting bracket.

(2) *Release link.* Remove the release link screw. Lift the end of the link off the lug

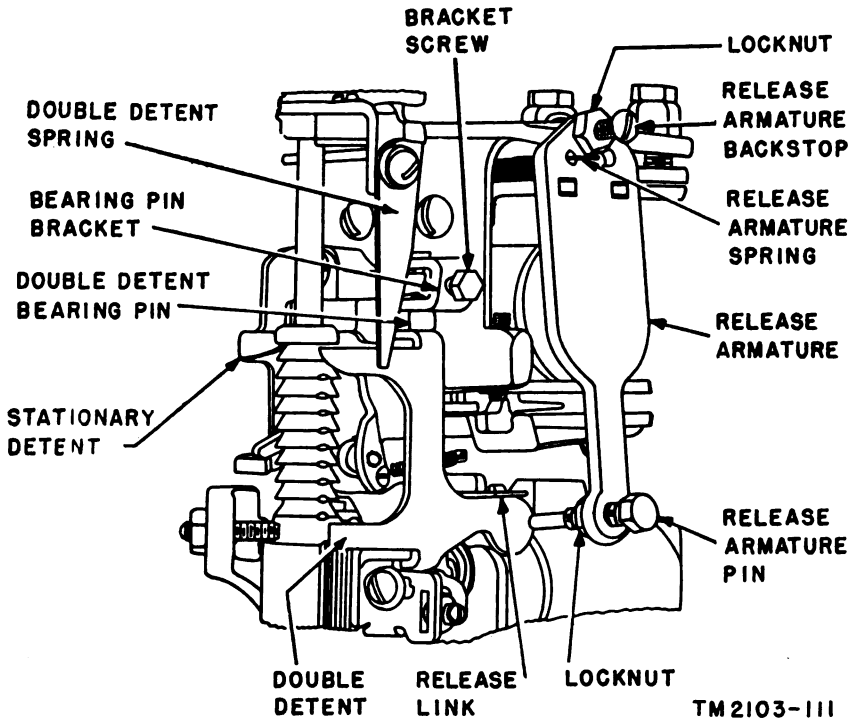


Figure 91. Release mechanism of two-motion stepping switch.

on the double detent and withdraw the link. Place the new link in position with the slot in the end hooked over the lug on the double detent. Replace the link mounting screw. Adjust the position of the link and tighten the screw.

d. Replacing Double Detent, Spring, Bearing Pin Bracket, or Bearing Pin. Remove the detent spring mounting screw and the detent spring. Lift the release link off the lug on the double detent. Loosen the bearing pin bracket setscrew. Slide the bearing pin upward until the bracket and the double detent can be removed. Replace the detent and the pin, if necessary. Slide the pin down through the detent and bearing pin bracket, and enter it in the hole in the switch frame. Tighten the bracket setscrew just enough to hold the bearing pin in place. Adjust the position of the detent, then tighten the bearing bracket setscrew securely. Replace the detent spring and spring mounting screw. Aline the spring with the center line of the switch shaft and tighten the mounting screw.

e. Replacing Parts in Vertical Stepping Mechanism.

(1) *Vertical armature assembly* (fig. 22). Release the tension from the double detent spring (figs. 22 and 91). Loosen the detent bearing pin bracket and remove the pin. Remove the double detent. Remove the end of the vertical armature restoring spring from the spring adjusting screw, and swing the spring away from the screw. Loosen the vertical armature bearing pin bracket. Push the armature pin toward the left side of the switch, and remove the pin completely. Drop the rear end of the armature far enough to clear the switch frame. Remove the armature from the right side of the switch. Clean all protective lubricant from the new armature with solvent (SD), and wipe dry. Place the new armature in position by reversing the removal procedure. Insert the pin from the left side of the switch. Line up the armature with the right hand while pushing in the pin. Push the pin through until the end is flush with the bracket. Tighten the bracket. Replace the double detent and tighten the double detent spring screw. Swing the armature restoring spring so that the end will engage the adjusting screw. Lubricate in accordance with lubrication instructions in paragraph 21.

(2) *Vertical armature bearing pin bracket and bearing pin.* Loosen the bearing pin bracket screw. Remove the end of the vertical armature restoring spring from the head of the adjusting screw. Swing the spring to the right until it clears the adjusting screw. Push the bearing pin toward the left side of the switch until it clears the bearing pin bracket. Replace the bracket. If the pin is to be replaced push until it clears the switch frame. If the pin is tight, drive it out with a light hammer and a pin punch. Insert the new pin from the left side of the switch. Push the pin through the armature and the bracket until the end is flush with the edge of the bracket. Check the armature for side play, then tighten the bracket. Replace the armature restoring spring under the head of the adjusting screw.

(3) *Vertical pawl spring.* Loosen the double detent bearing pin bracket screw. Release the tension of the double detent spring. Raise the detent shaft until the detent is free. Remove the detent. Unhook the pawl spring from the pin in the vertical armature and the hole in the vertical pawl. Hook the open end of the new spring in the pawl so that the open end faces toward the detent. Place the closed end of the pawl spring over the pin. Raise the vertical armature. The tension of the new spring should pull the pawl into its extreme forward position. Replace the double detent. Slide the

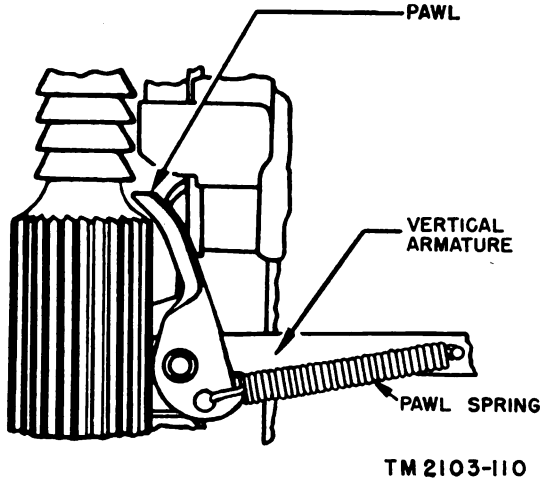


Figure 92. Vertical pawl spring.

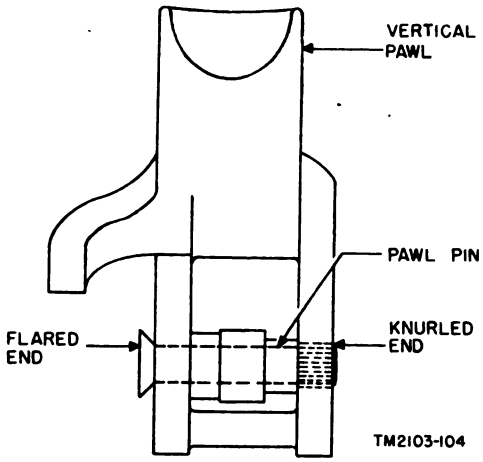


Figure 93. Vertical pawl and pawl pin.

detent pin down until it enters the hole in the switch frame. Adjust the bearing for detent and play, then tighten the bearing pin bracket screw. Tighten the detent spring retaining screw.

(4) *Vertical pawl and pawl pin.* When the vertical pawl or the pawl pin must be replaced, remove the vertical armature. Hold the armature securely, and file off the flared end of the pawl pin (fig. 93). Use a punch with a point smaller in diameter than the pawl pin, and a soft-faced hammer. Place the point of the punch against the filed end of the pin, and carefully drive the pin out of the holes in the pawl. Install the new pawl and pin.

(5) *Vertical off-normal spring assembly.* Unsolder the leads to the spring terminals. Raise the switch shaft to the tenth vertical level. Using an offset screw driver, remove the two screws holding the spring assembly mounting bracket to the switch frame. Remove the bracket and spring assembly. Place the new assembly and bracket in position and insert the screws. Tighten the screws securely. Attach the leads to the proper terminals and resolder. Restore the switch shaft to its normal position. Make sure that the new contact assembly makes and breaks as required.

f. Replacing Switch Shaft and Associated Parts.

(1) *Helical-type shaft spring and associated parts.* To replace the shaft spring, turn the spring cap by hand in a clockwise direction. Then lift the cap so that the spring terminal

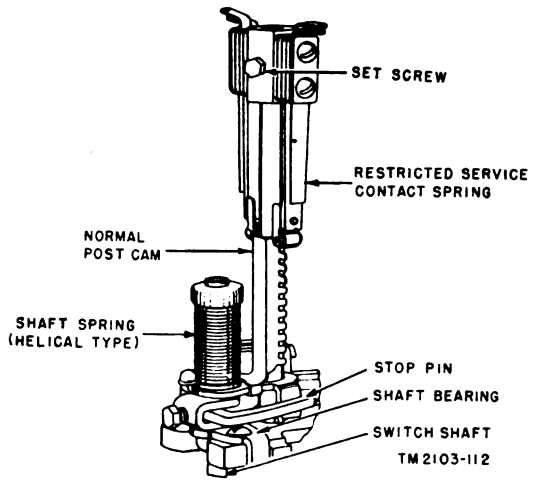


Figure 94. Helical-type shaft spring, normal post contacts, and cam.

is free of the slot in the shaft extension sleeve. Unwind the spring slowly. Disengage the lower loop of the spring from the lug on the shaft spring bracket and remove the spring by lifting it off the shaft extension sleeve. Lubricate the switch shaft as covered in the lubrication instructions in paragraph 21. Place the new spring over the shaft extension sleeve. Engage the lower loop of the spring with the lug on the shaft spring bracket. Turn the shaft spring cap by hand in a clockwise direction one to 1½ turns, until the spring end engages the bayonet slots in the shaft extension sleeve.

(2) *Shaft spring bracket.* To replace the shaft spring bracket, first remove the normal post contact assembly from switches so equipped, by loosening the setscrew and lifting the assembly from the normal post. Then remove the shaft spring. Remove the shaft spring bracket by lifting it upward until it is free of both the shaft extension sleeve and the normal post. Guide the new shaft spring bracket into position with its bearing over the shaft extension sleeve and the rear of the shaft spring bracket encircling the normal post. Observe that the normal pin stop is between the normal post and the normal pin, and replace the shaft spring.

(3) *Normal pin.* Before replacing the normal pin remove the helical-type shaft spring. Loosen the normal pin clamp screw and withdraw the normal pin. Turn the shaft extension sleeve so that the key slot in the

sleeve coincides with the slot in the switch shaft. Locate the normal pin bracket screw opposite the slots in the shaft and sleeve. Insert the normal pin in the normal pin bracket so that the pin engages the slots in both the shaft and the sleeve. Turn the normal pin bracket screw until the point of the screw touches the normal pin. Check to be sure that the normal pin engages the slot in both the shaft and the shaft extension sleeve. The movement of the sleeve should be limited by the normal pin. If the pin engages the slot in the extension sleeve only, the extension sleeve will be free to turn on the switch shaft. Tighten the clamp screw carefully, so that the screw does not shear, or the shaft does not bend. Replace the shaft spring in its original position (fig. 94).

(4) *Normal pin bracket and shaft extension sleeve.* Remove the helical-type shaft spring, then lift the shaft spring bracket until it clears the shaft extension sleeve. Turn the bracket on the normal post so that it will not interfere with the removal of the normal pin bracket. Remove the normal pin and then lift the normal pin bracket and the shaft extension sleeve from the switch shaft. Replace the shaft extension sleeve on the switch shaft. Place the new normal pin bracket over the shaft extension sleeve and then tighten the normal pin in position, observing that the normal pin bracket strikes the upper shaft bearing squarely. If the normal pin clamp strikes the upper shaft bearing on one side instead of squarely, turn the normal pin bracket so that the surface formerly adjacent to the shaft spring bracket is adjacent to the upper shaft bearing. If the normal pin bracket still fails to strike squarely, use another normal pin bracket that does strike squarely. Tighten the normal pin bracket screw carefully. Replace the shaft spring bracket and shaft spring in the original position.

(5) *Normal post contact assembly.* Unsolder the leads connected to the normal post contact springs. Loosen the setscrew holding the normal post contact assembly bracket to the normal post and lift the assembly from the top of the normal post (fig. 94). In certain cases where there are left and right normal post contact assemblies, it will be necessary, in order to replace the right assembly, to remove the left assembly first. Place the new contact assembly in position. Adjust it so that the contact springs operate properly. Solder the leads to the terminals.

(6) *Normal post cam.* To replace the normal post cam, first remove the normal post contact spring assembly. Remove the shaft spring and shaft spring bracket. The normal post cam can then be removed from the shaft spring bracket. Place the new normal post cam on the shaft spring bracket. In certain cases it may be necessary to pry apart the sides of the normal post cam slightly so that it fits over the normal post. Mount the shaft spring bracket, at the same time guiding the lugs on the upper part of the normal post cam onto the normal post. Mount the shaft spring bracket and remount the normal post spring assembly (fig. 94). Adjust the teeth on the new cam to conform with the requirements. These requirements will usually be the same as on the old cam.

(7) *Upper shaft bearing and oil wicks.* Remove the shaft spring assembly, brackets, and associated parts. Loosen the double detent spring mounting screw and swing the spring toward the front of the switch so that it disengages. Remove the two mounting screws from the upper shaft bearing and remove the bearing together with the spring, felt washers, and washer holder from the top of the shaft. Replace these parts at this time, if necessary. If the felt washer oil wicks are replaced, apply 3 dips of oil to each of the wicks after they have been installed. Use either brush TL–72 or a No. 6¼ round brush (Signal Corps stock No. 6Z1413) to apply the oil. Reassemble the parts. Loosen the lower bearing mounting screws and shift the shaft as far to the rear of the switch as the holes in the bearings permit. Tighten the bearing mounting screws securely.

(8) *Cam collar.* Remove the screws from the cam collar, using the 3-inch cabinet screw driver. Place the point of the screw driver between the two clamping surfaces of the cam collar. Spread the cam collar open until it can be removed from the shaft.

Spread the new cam collar in the same manner and place the new collar in position on the shaft. Squeeze the cam collar together with the long-nose pliers and replace the cam and the cam clamp plate. Adjust the cam to its proper position for operating the cam springs and tighten the clamping screws securely.

(9) *Shaft.* Remove the shaft spring assembly and upper shaft bearing. Loosen the setscrew in the wiper hubs. Remove the bank contact wipers from the shaft. Remove the two mounting screws from the lower shaft bearing with the 3-inch cabinet screw driver and remove the oil wicks and holder from the lower end of the shaft. In some cases it may be necessary to loosen the two screws holding the lower plate to the switch frame to permit the lower shaft bearing to be moved forward. Hold the top of the shaft between the thumb and forefinger and grasp the lower part of the shaft at the point just below the lower plate. Exert a slight pressure toward the front of the switch in order to move the lower shaft bearing far enough to permit the removal of the shaft. If the shaft is equipped with a cam, remove the cam from the old shaft and mount it on the new shaft. Use a new lower shaft bearing where necessary. Place the lower shaft bearing in its position between the frame and the lower cover plate. Insert the shaft through the bearing and the lower cover plate from above. Place the oil wick and holder on the shaft from below and partially tighten the bearing mounting screws. Replace the upper shaft bearing, the normal pin clamp, normal pin, shaft spring bracket and shaft spring on the switch, using new parts where necessary. Press the shaft as far toward the rear of the switch as the holes in the shaft bearings permit and tighten the bearing mounting screws securely. Replace the bank contact wipers on the shaft.

66. Repairs to Wiper Cords and Wipers (figs. 95, 96, 97, and 98)

a. Wiper Cords. When wiper cords are to be replaced, unsolder the cord terminals from the terminal and test jack block and from the wiper terminals. Remove the surplus solder from the terminals. Do not apply excessive heat when unsoldering; excessive heat will damage the parts. Do not unsolder the leads of any wipers that are not being replaced. When installing new wiper cords, make sure each wiper is connected to the proper terminal. Figure 95 shows wipers and wiper cord terminal arrangement on switches equipped with three bank contact wipers and a vertical commutator and wiper. Figure 96 shows wiper cord terminal arrangement for switches having three bank contact wipers and no vertical wiper and commutator. On switches having only two wipers, the numbering is the same as for the first two wipers in figures 95 and 96.

(1) When installing a wiper cord, push the cord tip over the terminal on the test terminal board, first making sure that the insulating tubing is in place on the longest terminals (fig. 97). Carefully solder the terminals, taking care not to use excess solder; be sure that the terminals are not short-circuited.

(2) Connect wiper cords to wipers having cord holders as shown in A of figure 98. Connect wiper cords to wipers that do not have cord holders as shown in B of figure 98. Note that the cords are turned at a slight angle inward, with a minimum spacing between terminals of one-fourth inch. Solder the terminals carefully.

(3) When installing the wiper cords on switches equipped with vertical wipers and cord holders, pass the new cords through the cord holders. Dress and tie the cords as shown in figure 95.

(4) Dress and tie cords for switches not having vertical wipers as shown in figure 96. Do not tie the cord for the upper wiper unless it has excess slack. On switches having only two wipers and three wiper cords, it is not necessary to tie the cords.

(5) Make sure that the cords do not become twisted or kinked. Try the switch shaft at the first and tenth vertical levels and all rotary positions to determine that the cords have sufficient slack and do not catch on or interfere with the vertical commutator, when used.

b. Wipers. When replacing bank contact wipers, unsolder the wiper cord tips from the wiper and loosen the wiper setscrew. If it is necessary to remove any other wipers from the shaft in order to remove the wiper being replaced, do not unsolder the wiper cords from the other wipers.

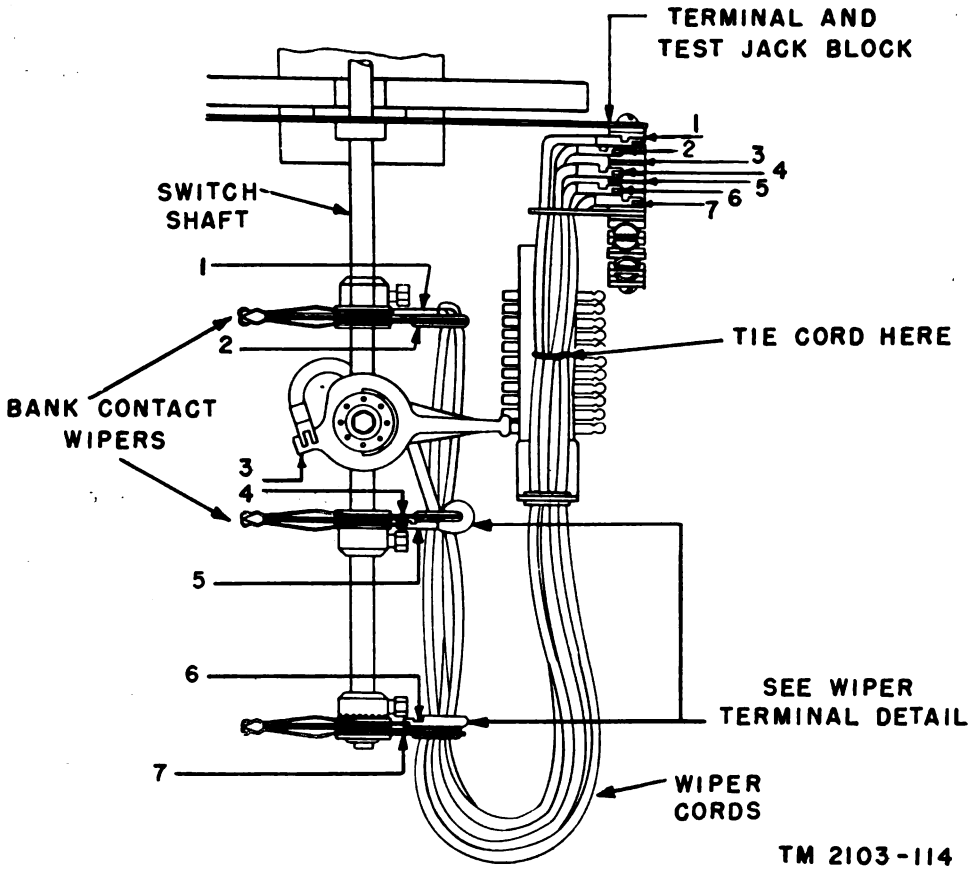


Figure 95. Bank wiper and vertical wiper cords, method of connection.

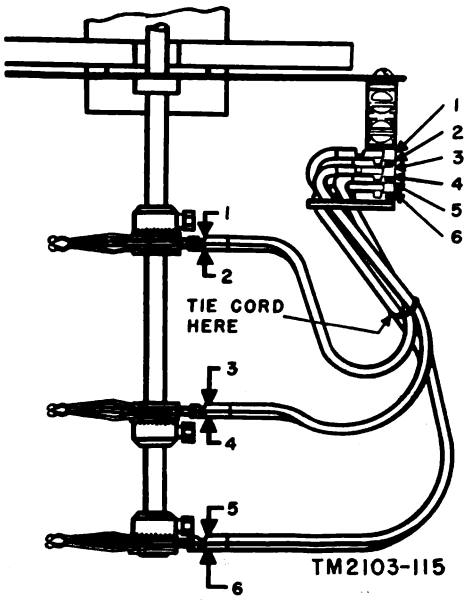


Figure 96. Bank wiper cord arrangement when no vertical wiper is used.

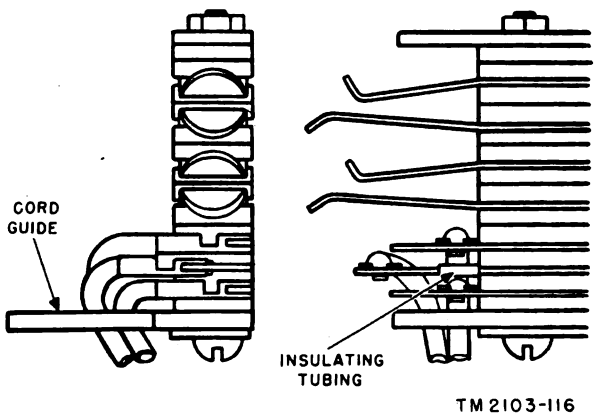


Figure 97. Wiper cord connections at terminal and test jack block.

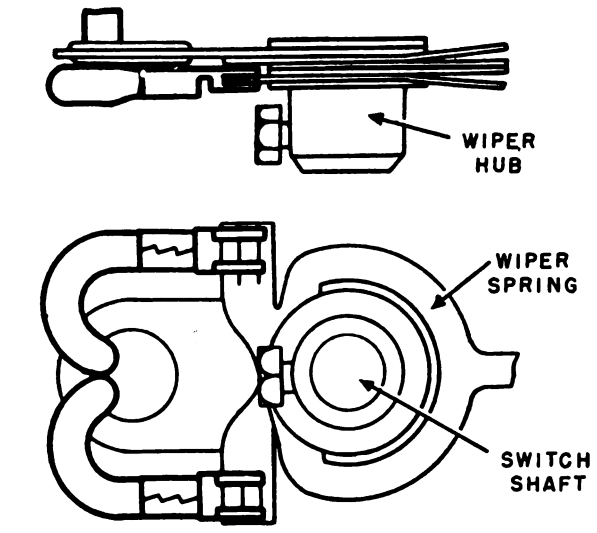


Figure 98. Wiper cord connections.

(1) When the wipers are removed, clean the bank contacts (par. 14). Install the new wiper with the hub in the same position as the wiper that is replaced. Operate the switch to the first vertical level and the first rotary position. Line up the wipers carefully, and tighten the setscrews.

(2) Always replace wipers with the same type of wiper originally used on the switch. If only one type of bank wiper is to be stocked for replacement, use the wiper equipped with cord guide or holder, since it can be used in place of wipers not requiring cord guides.

(3) When wipers having cord guides are not available for replacement on switches having vertical wiper and commutator, wipers without guides may be used only for emergency repairs. In this case, wrap one turn of friction tape around the cords adjacent to the wipers. Tie the cords to the wiper terminals with linen lacing twine.

67. Operating Requirements

After repairing switches, test with the stepping-switch test set or the test telephone handset. Adjust the vertical and rotary armature, if necessary, until the switch operates smoothly. Do not increase the tension of the magnet armature restoring springs more than is necessary. Tension less than 450 grams usually provides best operation.

a. If the switch does not perform its vertical and rotary stepping properly, recheck the adjustments in accordance with paragraphs 46 through 48. If the switch does not perform properly when adjustments are correct, check the vertical and rotary magnet coils, the interrupter contacts, and relays. Readjust relays if necessary.

b. If the switch shaft rebounds, after it returns to vertical normal, sufficiently to permit the vertical off-normal springs to operate and cause circuit trouble, it may be due to the normal pin bracket not striking the upper shaft bearing squarely. If the normal pin bracket strikes the upper shaft bearing on one side instead of squarely, remove the shaft spring assembly and the normal pin. Reverse the normal pin bracket on the switch shaft so that the surface of the bracket formerly adjacent to the shaft spring bracket is adjacent to the upper shaft bearing. Reassemble the normal pin in the normal pin bracket, tighten the normal pin clamp screw, and observe whether the bracket strikes the upper bearing squarely. If it does not, replace the bracket with one that does strike the bearing squarely. After this is done, reassemble the shaft spring and its associated parts on the switch shaft and readjust the shaft spring and the normal pin to meet requirements.

c. Check to make sure that the adjustment of the stationary detent has not been disturbed in reversing the normal pin bracket. The 0.004-inch clearance between the front side of the stationary detent and the teeth of the vertical ratchet can be used as a visual check.

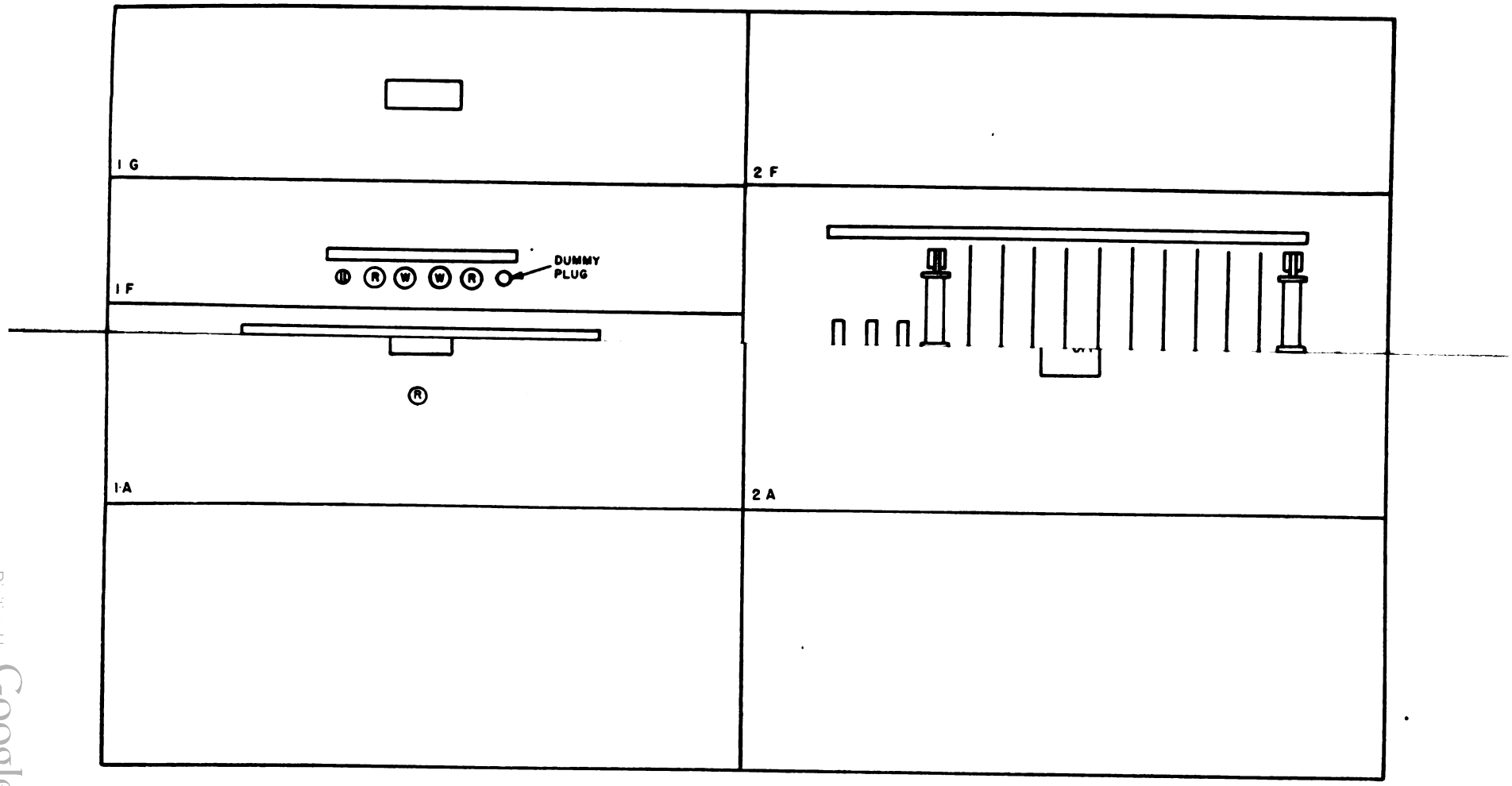
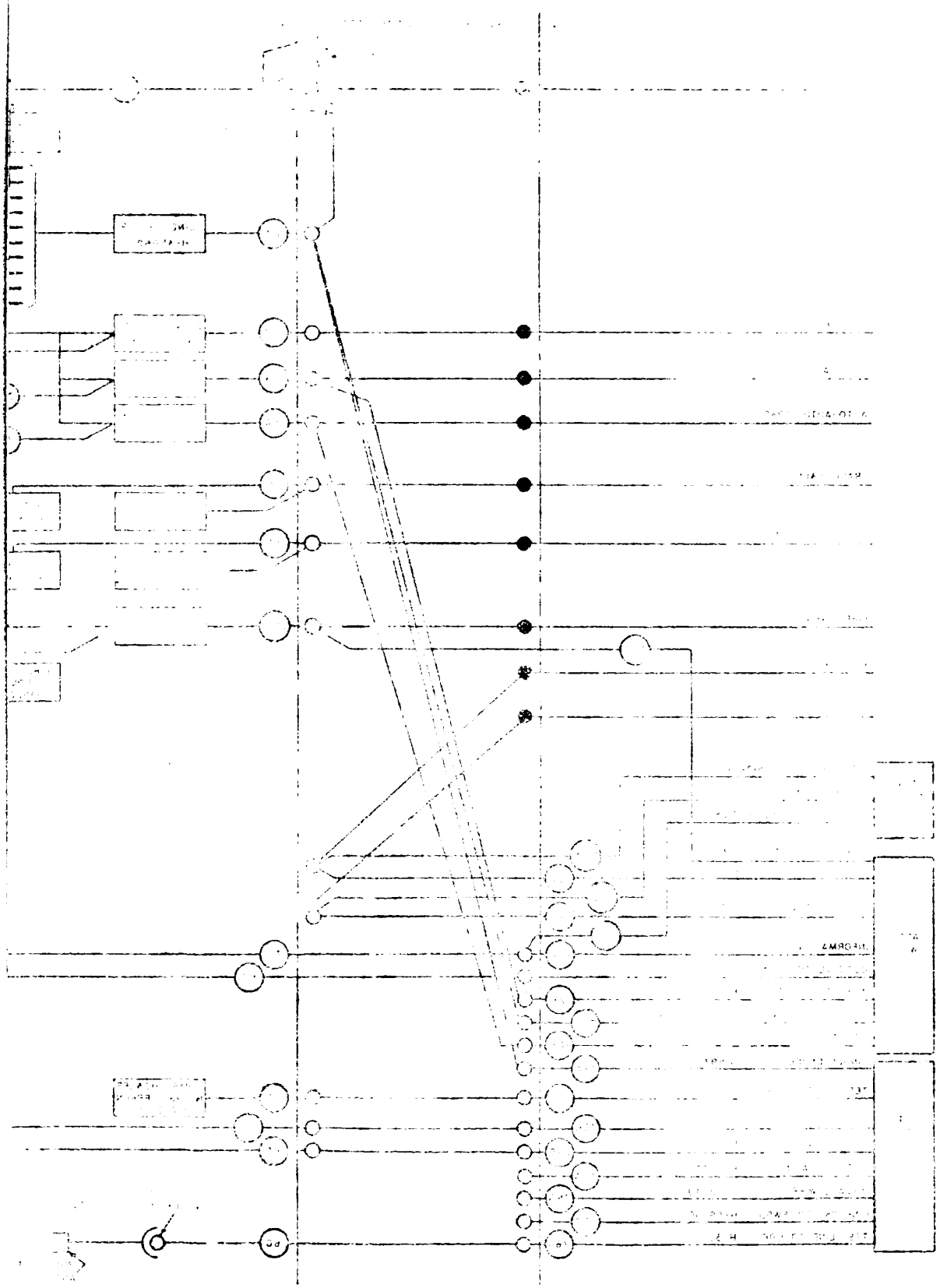


Figure 99. Typical power board, front view.



APPENDIX I

REFERENCES

Note. For availability of items listed, check SR 310-20-3 for field manuals, training circulars, training aids, Army training programs, JANAP's, tables of organization and equipments, tables of allowances, and tables of basic allowances. Check SR 310-20-4 for technical manuals, technical bulletins, supply bulletins, modification work orders, and changes. Check Department of the Army Catalog SIG 1 for Signal Corps supply catalogs.

1. Other Technical Manuals on Step-by-Step Dial Central Office Equipment

TM 11–2100	Fundamentals (Step-by-Step Dial Central Office Equipment).
TM 11–2102	Installation Instructions (Step-by-Step Dial Central Office Equipment).
TM 11–2104	Linefinder Equipment (Step-by-Step Dial Central Office Equipment).
TM 11–2105	Selectors and Connectors (Step-by-Step Dial Central Office Equipment).
TM 11–2106	Miscellaneous Switching Equipment (Step-by-Step Dial Central Office Equipment).
TM 11–2107	Attendant's Switchboard (Step-by-Step Dial Central Office Equipment).
TM 11–2108	Power, Ringing, and Supervisory Equipment (Step-by-Step Dial Central Office Equipment).
TM 11–2109	Distributing Frames and Line and Trunk Assignments (Step-by-Step Dial Central Office Equipment).
TM 11–2110	Test Desk Equipment and Technique (Step-by-Step Dial Central Office Equipment).
TM 11–2111	Tools, Testing Equipment, and Common Supplies (Step-by-Step Dial Central Office Equipment).
TM 11–2112	Current-Flow Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2113	Connector Routine Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2114	Stepping-Switch Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2115	Crash and Conference Equipment (Step-by-Step Dial Central Office Equipment).

2. Supply Publications

SIG 1	Introduction and Index.
SIG 3	List of Items for Troop Issue.
SIG 4-2	Allowances of Expendable Supplies of Tactical Organization, Training Centers, Boards, and Fixed Installations.
SIG 6–ME–10	Maintenance Equipment ME–10.
SIG 6–TE–49	Tool Equipment TE–49.
SIG 6–TE–111	Tool Equipment TE–111.
SIG 6–TE–112	Tool Equipment TE–112.
SB 11–76	Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.

3. Technical Manuals on Test Equipment

TM 11–346	Test Sets I–61–A, I–61–B, and I–61–C.
TM 11–2017	Test Set TS–26/TSM.
TM 11–2019	Test Set I–49.
TM 11–2036	Test Set I–181.
TM 11–2050	Test Set I–48–B.
TM 11–2057	Test Set TS–27/TSM.
TM 11–2062	Test Set I–142 and Test Set I–142–A (Telephone).
TM 11–2613	Voltmeter I–166.

4. Technical Publications on Theory, Maintenance, and Repair

TB SIG 25	Preventive Maintenance of Power Cords.
TB SIG 66	Winter Maintenance of Signal Equipment.
TB SIG 72	Tropical Maintenance of Ground Signal Equipment.
TB SIG 75	Desert Maintenance of Ground Signal Equipment.
TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TM 11–457	Local Battery Telephone Equipment.
TM 11–458	Common Battery Telephone Equipment.
TM 11–468	Substation Maintenance.
TM 11–473	Central Office Maintenance (Manual).
TM 11–475	Principles of Long Distance Telephone and Telegraph Transmission.
TM 11–487	Electrical Communication Systems Equipment.
TM 11–498	Fundamentals of Telephony and Manual Telegraphy.
TM 11–676	Grounding Procedure and Protective Devices.
TM 11–757	Principles of Line Fault Location.
TM 11–4302	Tactical Switchboards and Long Lines Equipment—Repair Instructions, Apparatus Requirements.
TM 11–4700	Electrical Indicating Instruments and Test Sets, Repair Instructions.

5. Painting, Preserving, and Lubrication

TB SIG 13	Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 69	Lubrication of Ground Signal Equipment.

6. Packaging and Packing Instructions

a. Joint Army-Navy Packaging Specifications.

JAN–D–169	Desiccants, Activated.
JAN–P–100	General Specification.
JAN–P–106A	Boxes, Wood, Nailed.
JAN–P–116	Preservation, Methods of.
JAN–P–125	Barrier Materials, Waterproof, Flexible.
JAN–P–131	Barrier Material, Moisture-Vaporproof, Flexible.

b. U. S. Army Specifications.

100-2	Marking Shipments by Contractors (and Signal Corps Supplements thereto).

c. Signal Corps Instructions.

720–7	Standard Pack.
726–15	Interior Marking.

7. Decontamination

TM 3–220	Decontamination.

8. Demolition

FM 5–25	Explosives and Demolitions.

9. Forms

DA AGO Form 11–23, Telephone Trouble Report.

DA AGO Form 11–24, Weekly Storage Battery Report.

WD AGO Form 11–145, Line Record Card.

WD AGO Form 11–146, Cable Record.

WD AGO Form 11–147, Cable Work Sheet.

DA AGO Form 11–206, Daily Trouble Record.

DA AGO Form 11–207, Routine Progress Record.

DA AGO Form 11–208, Connector Terminal Record.

DA AGO Form 11–209, Linefinder Terminal Record 11 to 00 (Card 1).

DA AGO Form 11–209–1, Linefinder Terminal Record 111 to 100 (Card 2).

APPENDIX II

GLOSSARY OF ABBREVIATIONS

Note. Prefixes and suffixes identifying manufacturer's drawings are listed in paragraph 37; a list of authorized abbreviations used in recording trouble is given in paragraph 38.

Abbrev.	*Definition*
ac	alternating current (noun)
a-c	alternating-current (adjective)
adj	adjusting, adjustment
alm.	alarm
amp	ampere
ans	answer
arm.	armature
assem	assembly
auto.	automatic
Auto Elec	Automatic Electric Company
BAT, bat.	battery
bd	board
bkdn*	breakdown
bldg	building
bsy*	busy
cap.	capacitor
CB	common battery
CDF	combined distributing frame
chg*	charge
clrd	cleared
ckt	circuit
comb.	combined
conf	conference
conn	connector (2-motion stepping switch)
cont*	control
csk	countersunk
D**	desk
dc	direct current (noun)
d-c	direct-current (adjective)
diam	diameter
dim.	dimension
disch*	discharge
dist	distributor (rotary stepping switch); distributing
DT	dial tone
ECV*	end-cell voltage
equip.	equipment
exch*	exchange
exten**	extension
F	Fahrenheit
FA*	fuse alarm
fig.	figure
ft	foot
gal	gallon
gen*	generator, general
gnd	ground
grav**	gravity
grp	group
H*	horizontal
hex.	hexagon
HU*	hold-up
HV*, hv	high voltage
IDF	intermediate distributing frame
in.	inch
ins*	insulate, insulation
insp*	inspector's
inst*	installer
int*	interrupted, interrupter
JAN	Joint Army and Navy
L	line
lb	pound
LB*	lower bank
LF	linefinder (2-motion stepping switch)
loc	local
LV*	low voltage
MA, ma	milliampere
man.	manual
max	maximum
MDF	main distributing frame
MF, mf	microfarad
mfr	manufacturer
MG*	motor generator
MGFA*	motor-generator fuse alarm
mgt	magnet
min	minimum
mod*	model
mon*	monitoring
mtd	mounted
mtg	mounting
mult**	multiple
neg*	negative
N OPR*	nonoperate

* Used only on manufacturer's drawings, specifications, etc.
** Used only on old forms and records.

Abbrev.	*Definition*
NO*	nonoperate
No.	number
nor*	normal
O*	operate
OPR*	operate
opr	operator
oz	ounce
par.	paragraph
PBX	Private Branch Exchange
pc*	piece
perm*	permanent
plt	plate
PM	preventive maintenance
pos	positive
pos	position
pri	primary
R, r	resistance
RBT*	ring-back
RC*	reverting-call
RCO*	ring cut-off
rcvr	receiver
readj	readjust
rect	rectifier
reg	regular
rept*, reptr	repeater
res**	resistance
resid*	residual
restor	restoring
rev*	reverting, reverse
rheo*	rheostat
rls*	release
rly*	relay
RM*	ringing machine
rptd	reported
RT*	release trunk
rty	rotary
ry	relay
SA*	slow-acting

Abbrev.	*Definition*
SAE	Society of Automotive Engineers
SC**	Signal Corps
sig	signal
Sig C	Signal Corps
sec	second
sel	selector (2-motion stepping switch)
s.g.**	specific gravity
SO*	slow-operate
spec	specification
spec**	specific
spg	spring
spl	special
std	standard
ST SIG*	start signal
sub	subscriber
supy	supervisory
sw	switch
swbd	switchboard
t	temperature
tel**	telephone
temp	temperature
term.	terminal
thkness	thickness
tp	telephone
trans*, xmsn	transmission
TS	test set
tst*	test
V, v	volt
V*	vertical
W**	wall
W, w	watt
w/	with
WB*	Wheatstone Bridge
wdg	winding
WECo	Western Electric Company
W	wall
xmsm	transmission
xmtr	transmitter

* Used only on manufacturer's drawings, specifications, etc.
** Used only on old forms and records.

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